ENGINEERING

this issue

EORY OF GAMES

YSICAL SOCIETY
HIBITION:
TRUMENTS
R FLIGHT DATA

LDING ROUND
FLOWLINE:
.C.
LEVISION CENTRE

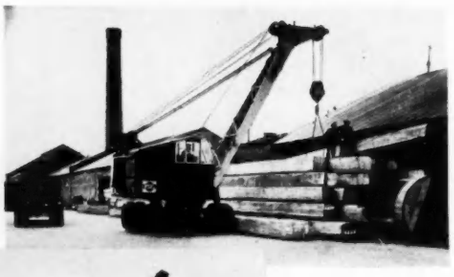
-PLUS
AMINATION
R ROAD VEHICLES

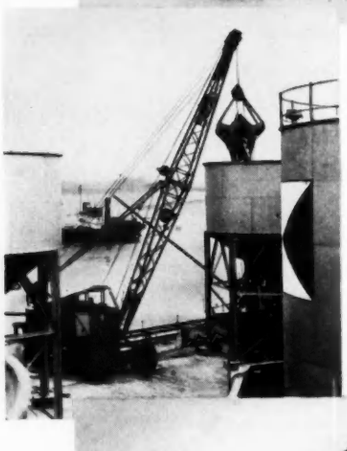
PRICE
2/-

Pumps

NEAL
MOBILE CRANES

in use throughout the world





Designed and manufactured in the highest tradition of British engineering skill, Neal cranes have that individual care and attention during all stages of construction which ensures that the Neal quality is always maintained.

THE NEAL STANDARD RANGE

Type NS 120 - 12 *tons*
Type NS 70 - 6 *tons*
Type NS 55 - 4/6 *tons*
Type NS 45 - 4 *tons*
Type GM - 15 *cwts.*

Write direct for further details and specification of the Neal full range

R. H. NEAL & COMPANY LIMITED
HEAD OFFICE · PLANT HOUSE · EALING · LONDON · W.5 · WORKS · GRANTHAM · LINCS.

Vol. 185 No. 4802 21 March 1958

ENGINEERING

PUBLISHED EVERY FRIDAY

Contents

353 **Leading Article**
What Kind of Bird?

354 **Plain Words**

355 **Letters to the Editor**
Accelerated Curing Tests on Concrete
Scuffing
Typing Mathematical Manuscripts
Engineers and the Guild

Special Articles

362 Building Round a Flowline: B.B.C. Television Centre
380 Speed and Industrialisation—and Population

365 **Atomic Review**
Ready for the Day

367 **Companies in the News**

368 **In Parliament**

371 **Automobile Engineering**
Ten-Plus Examination for Road Vehicles
Motoring to the South Pole

374 **Book Reviews**
History of the British Iron and Steel Industry
Surveys of Indian Industries
Human Engineering

375 **New Books**

375 **On the Shelf**

383 **Notices of Meetings**

384 **Engineering at Home**
Film to Protect Surfaces
Underfloor Air-Feed
Anamorphic Lens for 8 mm Films
Sandwich Boards
Transformer Plugs

. . . . . .

Management

354 Weekly Survey
369 Theory of Games: A Tool for Operational Research

357 **Plant and Equipment**
New British Crop-Spraying Aircraft
Gas Furnace for Glassware
Recording Photographs Magnetically
Glandless Stop Valve
High Power Germanium Rectifier
Electricity on Show: Electrical Engineers' Exhibition

361 **The Human Element**

373 **Research and Development**
Instruments for Flight Data: 42nd Physical Society Exhibition

376 **Design**
Runners of Experimental Turbomachines: Defining Vane Shapes
Mechanism Efficiency Nomograms
Suspension Pipe-Bridge
High Efficiency Hydraulic Transmission
4,000,000 Hours by Dart Turboprops

381 **Production**
Making Scientific Glassware
Control of Strip Width in Hot Rolling Mills
Oil-Engine Works Modernised

What Kind of Bird?

THERE is a widespread impression that too much money is spent on advertising, and that some of that money would be better spent on providing more of the good things of life. Certain politicians are said to relish the thought of taxing this large expenditure. As a source of tax revenue for the State it has two advantages: advertising is readily represented as wasteful, and it might be taxed without offending the individual voter. The attack on advertising has thus put advertisers and their agents on the defensive. Paradoxically, of all the goods and services that are advertised, the one that is seldom advertised is advertising itself. Its function in the economy is therefore seldom understood. It is a sitting target for the glib critics. The unfortunate bird can do very little to save itself, except by spending more money to advertise advertising—a way out that would increase the size of the target and make it impossible for even the worst shot to miss.

How do advertising men explain the function of their work? In one attempt to give a definition it was decided that a suitable definition should "cover any activity designed to spread information with a view to promoting the sales of marketable goods and services." The "information" idea, however, is not entirely appropriate. Dr. Mark Abrams, in an article last year, suggested that the idea of "persuasion" was more realistic. He defined advertising as "any communicative activity by a seller to attach consumers' choice to particular goods and services." He showed that producers of goods are constantly driven to fresh efforts to maintain the demand for their products against their competitors'—and to do this they must advertise. Firms are driven along the path of innovation by seeking to hold their competitive positions. Whether it is persuasion or information, advertising is certainly a form of communication, and it is when we look at the pattern of communication—of thousands of manufacturers, shops and customers—that we begin to appreciate that the £330 million or more which is spent on advertising in this country every year, though it is a large figure, is relatively small compared with the total national production.

In the United Kingdom there are more than 56,000 manufacturing establishments, There are also, surprisingly, the same number of wholesale establishments. There are well over half a million retail establishments. And there are nearly 50 million consumers who are susceptible to advertising. Consider the complexity of the pattern of communication required to keep this industrial structure going. It boasts a "gross national product"—the total output by the nation of goods and services together with the net income from abroad—of £18,000 million, and of this total it spends £330 million, or about 1·8 per cent, on advertising. A proportion of 1·8 per cent is not much for a country which is not backward in innovation and is making many products that did not even exist ten years ago. The critics of advertising usually fasten on the promotion of such domestic products as detergent powders and razor blades, but these, being products which are bought by a large section of the population, and being bought at frequent intervals, lend themselves to extensive advertising. If there is any criticism to be made it is not that these products are over-advertised but that the more specialised products are not advertised enough.

Unlike products for home consumption, engineering products are of special importance because they account for so much of our exports. The value of manufactured goods exported in 1956 was £2,620 million, and the biggest slice of this total was due to machinery (excluding electrical machinery), which accounted for £504 million. Electrical machinery brought in £217 million, and road vehicles and aircraft another £372 million. These substantial achievements were made possible largely by advertisements in technical journals which circulate abroad. Of this journal's total circulation, for example, about 37 per cent goes abroad. If a tax is put on advertising, without regard to the effect on the engineering industries, it will be a tax on exports.

On the credit side for advertising we must, finally, recognise the part it plays in paying for the communication of editorial information, whether in newspapers or technical journals. The Press of this country combines to serve both the advertiser and the reader. That it is forced to be efficient is shown by the recent collapse of some well-known magazines; they no longer served both interests simultaneously. Those politicians who are loading their guns to shoot at advertising would do well to remember that without it their names and personalities would be unknown to the voting public. Of the £330 million, quite a high proportion subsidises the continual publicity of those few politicians who are national figures. Advertising is not a bird of prey; on the contrary, it is a bird of paradise—the paradise of those higher standards of living which link the politician and the voter.

Cover Picture. *Light weight fire-fighting pumps may be driven from conventional engines through step-up gears as shown in our picture (by Nurnberg) or coupled to a small gas-turbine.*

* * *

Plain Words

Why won't the boss leave me to work in peace? He's not a bad chap in his way, but he has too many ideas. I suppose that's how he came to be the boss. But all too often his ideas involve me, and, personally, I like doing things my way. It's not that his ideas are impossible, sometimes they're passably helpful; but they just don't happen to be mine. Someone should tell him. If he'd get on with his job, we could get along with ours, and a jolly sight more quickly too. The trouble is that his job is seeing I do my job, and it gives him a certain right to interfere. But it doesn't make him any easier to live with.

I've just read a book. It was about a writer who had once worked in a big organisation—one in which the memos fluttered down like snow. He gave it up; it was much too wearing. He was a really tough character, and he refused to be messed around. Quite right too. There were only two ways of living, he said, really living: one was to run things; the other was to contract out and let them run themselves. Mind you, it isn't everyone who can go off and live in the Canaries.

Of course, the boss has his troubles too: *his* boss has ideas on the grand scale. But what about the poor chap right at the bottom, who hasn't anyone to organise at all? It's all very well to talk about the dignity of labour, but how does the British working man retain his sturdy independence when he's being organised right, left and centre by managers, shop stewards, foremen, personnel officers and television? Badgered on every side by good advice and sales pressure, so hemmed about by alien ideas, he hasn't time for any of his own. As a result, our society may become muscle bound. It's something to do with the springs of human energy. Having our own ideas and working on them is a sort of stimulus, and without it, ideas and energy start to fade away. It's sometimes better to work on a second-rate idea of one's own, than on someone else's smasher.

Still, I'm not really being fair on the chief; he has his faults, but he's pretty tactful. He's got some line about making you think it was your idea in the first place, by hypnosis or suggestion or something. My wife's got the same tactics, only you can usually see it coming a mile off. Then there's the way he goes off into a coma when I'm trotting out my ideas. Reminds me of James Thurber, who "never listens when anybody else is talking, preferring to keep his mind a blank until they get through, so he can talk."

As Wells suggested in *The New Machiavelli*, every human being worth his salt has the desire to fashion the world, or part of it, in the palm of his hand. I have sometimes had the itch myself. And after all the boss is only human.

CAPRICORN

Weekly Survey

Critical Phase in the United States

With the publication last week of the February unemployment figures in the United States, the most difficult phase in the Administration's deflationary policy has begun. The February count showed a total unemployed of 5·2 million, the highest level for 16 years. There is little doubt that the increase of 700,000 unemployed over the January return was bigger than was expected by the Administration or by Congress. The President's reaction was publicly optimistic but Congress, which faces an election this year, is getting restless and the trade unions are becoming somewhat emotional. They are beginning to see a second era of the "forgotten man" with all the apprehension from 25 years ago which this brings with it.

The Administration is in a difficult position. Its economic advisers are clearly trying to carry out an intelligent deflationary policy which will make possible a reorganisation of the country's economic resources, especially in the capital goods industries, in new directions without a headlong and inflationary expansion such as appeared likely to develop in 1956. To succeed, that policy must not be discarded for a reflationary one too soon. This inevitably makes the Administration appear to be whistling to keep up its courage, to make not very convincing remarks about an upturn in March and to offer protestations that everything is going according to plan.

The worrying feature in the strategy being pursued by the United States Government is that if the timing is seriously wrong in squeezing out the last vestiges of inflation from the United States domestic economy the consequences on the rest of the world could be exceedingly serious. The rest of the world is afraid that the American determination not to reflate is going to start a deflation abroad which no one, and certainly not the Americans, will be able to stop until a good deal of economic damage has been done. If the Administration is right and the timing is successful it will have been no small economic *tour de force*.

Paradise Regained?

As yet nothing seems to be going wrong this year with the United Kingdom's external trading position. Britain continues to get the benefit so far as the value of its imports are concerned from the generally low level of world commodity prices; and exports, including those to the United States, remain buoyant. In the February trade returns published this week the United Kingdom's visible trade gap fell to £11 million which is the smallest deficit achieved in any normal month for over 10 years. The outstanding feature of the figures is that although total exports declined last month, shipments to the United States recovered strongly. It is one of the odd twists of luck which come a country's way once in a while that the American recession is increasing the interest of the United States market in inexpensive small foreign cars and the United Kingdom car industry is able to cash in on this.

The position is both comforting and dangerous. It would not be impossible for exports to drop off severely if the United States recession went on much longer and the purchasing power of primary producing countries does not begin to recover soon. This somewhat fortuitous strength in the external account is also being sustained by a system of high interest rates. Speaking to the Manchester Statistical Society last week, Professor Hicks gave it as his considered view that high interest rates must continue as long as this country's reserves of gold and foreign exchange are too low for them to act as a banking reserve for the Sterling Area. He thought that some form of international loan, on commercial terms through the International Monetary Fund, would be necessary to make sterling more viable. If he is correct, a temporary improvement in the external account will not be sufficient to bring interest rates down. If interest rates stay high without inflation getting out of hand—that is to say, if the long-term rate of interest is unattractive to companies from an investment point of view while there is no inflation or only one of the creeping variety—the outlook for the engineering industry is bleak.

Better Railways

Last week Mr. Harold Watkinson, Minister of Transport and Civil Aviation, talked of the progress made by British Railways since the modernisation programme was started two years ago. He was speaking at the annual luncheon of the Institution of Locomotive Engineers and had much to say that was both stimulating and encouraging. Progress is being made, if anything ahead of schedule, both in re-equipping and re-educating what he called "this great railway industry," to fit it "to play its full part in the new technological age."

Traction methods are being revolutionised. By the end of 1957 over a thousand diesel multiple units had been brought into service, some in inter-city traffic. Their popularity is measured by the increase in the number of passengers carried. The London Midland Region were carrying over 40 per cent more passengers last year than in 1956—at the rate of 1¼ million a month. The new electrification schemes are also going well and Mr. Watkinson was able to conclude that the public was showing that they can be drawn back to the railways "when the railways can give them the modern service which matches other forms of transport." The Minister was particularly enthusiastic about the attitude of the railways' employees, who have shown "a new spirit of co-operation in the introduction of new and almost revolutionary practices." He acclaimed the recent Diesel Manning Agreement between the Transport Commission and the unions as "a most heartening step forward."

Mr. Watkinson's review of the freight traffic problems was far less reassuring: he described the present trend of freight tonnage, particularly in merchandise and livestock, as "pointing too much downward for comfort." Improvements are being made, including better traction, continuous braking on freight wagons for greater speed and less marshalling, the introduction of special containers, palletisation and of roll-on/roll-off methods. The merchandise charges scheme will allow the railways to quote on more equal terms with other forms of transport, and do away with the rigidities of the old scheme. The reorganisation of commercial services will also help, though the C licence road transport would take a lot of beating, either on costs or convenience. He rejected any suggestion of regulating C licence transport which, he said, would be tantamount to placing "a tax on industrial productivity which the country can ill afford at the present time."

Better Use of Roads

An investigation is being undertaken by the Ministry of Transport into the use being made of commercial vehicles. A random sample of 8,000 vehicles is being picked from the records of licence groups maintained by the licensing authorities and the survey will include British Transport Commission vehicles. Operators of these vehicles are being asked to complete a form from the Ministry setting out details of

each vehicle and its movements during the seven days beginning April 21. Other information asked for includes type of goods carried, maximum load during each journey, numbers of miles run and details of itinerary. The last investigation of this kind was carried out in September, 1952, when the road haulage industry was still nationalised. Since that date about ¼ million more vehicles have been put on the roads, the nationalised fleet has been greatly reduced and restrictions on the use of non-nationalised vehicles have been lifted. The information is also wanted for international studies in connection with the Economic Commission for Europe, the European Conference of Ministers of Transport and the Transport and Communications Commission of the United Nations. The ninth session of the United Nations Economic Commission for Europe's Working Party on the Prevention of Road Traffic Accidents was held at Geneva last month. Proposals were made about level crossings, signposts, road markings, marking of vehicles and traffic problems. These proposals were sent forward as recommendations to the Economic Commission for Europe's Sub-Committee on Road Transport. There is thus a good deal of activity at the moment on the international standardisation of traffic control.

With its high traffic density, control of the movements of vehicles is particularly important in this country. The survey of the Ministry comes at an opportune moment when the denationalisation of road transport has had some chance to work out its effects on the ownership and movement of lorries against a background of rising traffic and deteriorating roads. In addition it should be possible to study the results of the survey with the knowledge that the new trunk road system has at last been started in a modest way and the modernisation of the railways, including marshalling yards, has made a certain amount of progress. Both the Road Haulage Association and the Traders' Road Transport Association have asked their members to co-operate in the Ministry's inquiry.

Research on Research Work

The latest survey of research and development to be published by the National Science Foundation in the United States contains interesting information on the employment of scientists and engineers in research and development. This publication—No. 9 in the series *Reviews of Data on Research and Development*—relates to the year 1954 but it is the first time such information has been collated. In that year, about 230,000 scientists were employed in research and development in the natural sciences (including engineering) and were engaged in activities involving the expenditure of some 5,400 million dols. Among them were 139,200 engineers and 89,800 physicists and life scientists (biologists), figures which represented roughly one-quarter of the engineers and two-fifths of the scientists employed in all activities.

The N.S.F. data reveal, therefore, that many people in the United States utilise their engineering and scientific training in other activities than research—such as production, teaching and administration—and that some do not use it at all. Among the 229,000 employed in research and development, 60 per cent worked in engineering and an additional 30 per cent in the physical sciences. The Federal Government employed 16,200 of the engineers but "industry-oriented organisations"—largely private industry—employed 116,000 or nearly 84 per cent of all engineers in research and development. Only 5,600, or 4 per cent of the total, worked in colleges and universities.

This information would be even more instructive, especially as a guide to the distribution of our own engineering effort in research and development, if the full analysis by industry were available. This will presumably be published in report form in due course. In particular, data on the qualification and training of the engineers and scientists concerned, and on the nature of the work they do (defined broadly as basic or applied research and development), would produce a useful yardstick by which British industry could measure its own efforts.

By Way of Colon

The February issue of the *F.B.I. Review* draws attention to the rapid growth of the autonomous Free Zone of Colon, less than half a mile from the Atlantic terminal of the Panama Canal, and the potential value of the zone to British exporters to Central and South America. The Free Zone was established by Decree Law in June, 1948, and in 1953 an area of 96 acres was fenced off for the erection of warehouses in which goods could be stored, repacked, assembled or refined without payment of duty. By the end of 1956, the authorities of the institution had invested about a million United States dollars in the construction of warehouses and the provision of services, while private investments in warehouses totalled about 700,000 dols., and the value of goods handled in the Zone had reached 40 million dols. per annum.

In addition to its close proximity to Cristobal, the Atlantic terminal of the Panama Canal, the Free Zone is linked by a 50 mile concrete highway with the International Airport of Tocumen, and it is claimed that even motor vehicles are being shipped by air from the Zone to Guatemala. Chemical and pharmaceutical products are shipped to the Zone, repacked and labelled there and then dispatched by air to various destinations in Latin America.

For the present, the greater part of the trade of the Free Zone is in the hands of United States manufacturers though European, Japanese and Australian companies have also established themselves. In many cases the facilities of the Zone enable manufacturers to improve the service offered to users of their products throughout South and Central America without the necessity of maintaining large duty-paid stocks in each of the countries concerned. There may well be a number of companies in the British engineering industry whose business in Latin America would benefit from the use of the facilities offered by the Free Zone.

Mechanicals Freed from Rates

The Institution of Mechanical Engineers has been exempted by the Lands Tribunal from paying rates in a decision handed down on March 11. The Mechanicals had appealed against a decision of the Central London Local Valuation Court which had turned down their contention that the Institution should be exempt from liability to rates since it is a scientific society under the Scientific Societies Act, 1843.

The President of the Tribunal, Sir William Fitzgerald, held that the Institution was founded for the purpose of science exclusively and allowed the appeal. He said that he accepted the contention that the promotion of the development of mechanical engineering means the increasing of scientific data so that things can be done in mechanical engineering by the application of discovered scientific principles and not by intuition or guess work. The valuation officer and Westminster City Council were ordered each to pay half the Institution's costs.

The Mechanicals are the first of the three senior engineering institutions to have their case heard before the tribunal although some of the other engineering organisations have already put their case without success. Even the I.Mech.E. are not entirely sure of their position since the Commissioners of Inland Revenue could conceivably take the case to the Court of Appeal. In an issue of this kind each case is considered very much on its merits, and precedents are not easily established. The three main criteria are that the organisation is a scientific one, that it uses its premises only for its own business and that it levies annual voluntary contributions.

Letters to the Editor

ACCELERATED CURING TESTS ON CONCRETE

SIR, I was interested to read the article on the above subject in your issue of 21 February (p. 243) by Mr. N. N. B. Ordman and Dr. N. G. Bondre and I am in full agreement with the authors on the potential value of oven-heating techniques on construction sites. Similar tests were made some while ago in the Civil Engineering Department of the University of Birmingham by a group of final year honours students. It was considered then that the tests would be worthless if they did not possess practical significance and every effort was made to simplify the equipment used, so that it could be simulated on construction sites. The investigation, while producing confirmation of the techniques used in the Port of London, differed in apparatus, procedure and scope in the following details:

1. The heating appliance used was an ordinary domestic gas-oven which had already seen service in some good lady's kitchen. The curing temperature was kept between 180° F and 190° F.
2. The top surfaces of the moulds were not covered during heating. Instead two water-filled tins (inherited from the previously mentioned lady) supplied humidity through the oven.
3. After two hours in the cooker the cubes were stripped and exposed to the prevailing dampness on all faces. Incidentally, only one cube was damaged by this procedure throughout the investigation.
4. Six hours was chosen as the curing period between casting and testing as this best suited the experimentors' University commitments. This meant that the cubes were actually in the oven for only five hours.
5. Parallel test series were applied using ordinary Portland concrete in one and rapid-hardening concrete in the other. In the case of both cements the correlation between the six-hour strengths and those at 7 and 28 days was high for the full range of mixes examined.

Engineers wishing to make use of oven-heating techniques on diverse construction sites should gain confidence from the fact that, despite the differences in equipment and procedure, both the Port of London tests and those conducted at Birmingham yielded convincing results.

Yours faithfully,
ROBERT HUMPHREYS.

30 Knowlys Road,
Heysham,
Lancashire.
15 March, 1958.

Editor's Note: Another letter on this subject appeared on p. 324 of our issue of 14 March.

SCUFFING

SIR, The problem of finding a reliable criterion of scuffing under boundary or thin film lubrication conditions has so far evaded a general solution. I would suggest that the following hypothesis could provide this solution.

At a contact we have a cause, i.e., work done at the contact, leading to a final end effect, i.e., a critical temperature rise and consequent melting and welding of the surface layers. This is obviously a rate-dependent process and, for a given set of conditions, the critical contact work rate per unit area at scuffing H_c, should be constant:

$$H_c = \mu P V = \text{constant} \quad . \quad (1)$$

where

μ = kinetic coefficient of friction;
P = the Hertzian stress; and
V = the sliding velocity.

The value of H_c will vary with the materials in contact, the lubricant used and the bulk temperature of operation, when it should be possible, by comparing the new critical work rate under any set of conditions with that of an appropriate reference standard, to derive suitable ratings for

Continuing Letters to the Editor

various material combinations, lubricants and temperatures of operation as follows:

$$H_{c1} = \mu_1 P_1 V_1 = K_M K_L K_T \mu_s P_s V_s. \quad (2)$$

where

μ_1, μ_s = coefficient of friction at the new and reference conditions, respectively;
P_1, P_s = Hertzian stress at the new and reference conditions, respectively;
V_1, V_s = sliding velocity at the new and reference conditions, respectively; and
$K_M K_L K_T$ = suitable ratings.

For engineering purposes the numerical values of K_M, K_L, and K_T are all that would be required for gear and other design purposes, but it should be emphasised that these ratings may not be dimensionless numbers. For example, K_L would represent a measure of the additional rate of work required to remove chemical or adsorbed films before the surfaces are in a fit condition for welding and might, ultimately, be shown to be a function of the thermodynamics of the chemical reaction occurring at the surface. This is over and above any effect the lubricant may have on the coefficient of friction. The ratings would be similar to, but not necessarily identical with, those suggested by H. D. Mansion (*J. Inst. Pet.*, vol. 38, p. 633, 1952).

Various scuffing criteria that have been proposed from time to time seem to be specific solutions of the general criterion now proposed. For example, J. O. Almen (p. 229, *Mechanical Wear*, published by the Amer. Soc. Metals, 1950) has proposed the criterion P V for spiral bevel gears. I would suggest that in his studies K_M, K_L, K_T and μ were all constant.

The same author, in that article, also proposed a P V T criterion for spur and helical gearing. I would suggest that in this study K_M, K_L, K_T were all approximately constant and that T, half the length of the line of tooth action, is a geometric measure of the coefficient of friction at the tip contact for a given pressure angle. The smaller slide/roll ratios of this type of gearing will imply a smaller value of μ which has rather important implications, as will be discussed later.

H. Blok (I.Mech.E., *General Discussion on Lubrication*, vol. 2, pp. 14 and 222, 1937) proposed a flash temperature criterion which he derived by going straight from the cause to the end effect, without considering in what way the work was done to produce the heat required to calculate the temperature rise. When this criterion is applied to extreme pressure oils, results are obtained which are sometimes difficult to interpret.

Insufficient regard has been paid in the past to the mutual interdependence of μ, P, and V as a search of the literature will show, but the use of available published and other data where μ, P, and V have been instantaneously measured tends to support the truth of the hypothesis.

I give two examples. The first is Figure 1 in F. P. Bowden's paper "The Friction of Sliding Metals" (I.Mech.E., *General Discussion on Lubrication*, vol. 2, p. 236, 1937), where temperature rises are plotted for various loads and sliding speeds for a lead rider sliding unlubricated on steel. If the curves are considered at the melting point (scuffing point) of lead, K_M, K_L, K_T and μ can all be considered constant and PV should then have a constant value, which it does to within $\pm$ 8 per cent approximately.

The second is in the paper by H. J. Watson, entitled "The Testing of Marine Main-Propulsion-Gear Lubricants in Disc Machines," presented at the I.Mech.E. Conference on Lubrication and Wear, October, 1957. In Figure 68.6, Mr. Watson presented friction torque curves for four sliding speeds using OM88 oil on En 36 discs at 70° C. The curves show incipient seizure as well as full seizure peaks on a smoothly increasing torque versus load curve. Calculation of the value of μPV as above defined for the points at which well marked incipient seizure or full seizure occurs gives a reasonably constant value as predicted.

The full significance of this is shown if μPV is plotted against the load (P being proportional to $\sqrt{\text{load}}$) where a curve becoming assymptotic to the critical value is obtained. It is easy to see that as the critical value of μPV is approached, the system is becoming unstable and a slight perturbation, such as a small particle of dirt, or vibration might be sufficient to bring about scuffing conditions, while the nearer the curve approaches the critical value the less chance of recovery there is. It will also be apparent why failure load is such a poor criterion for use in scuffing test methods.

Using the value of μPV derived from Figure 68.6, it is possible to calculate the value of μ at all sliding velocities in Figure 68.2, which is the characteristic U-type scuffing load versus sliding velocity curve obtained on disc machines. It is found that μ is diminishing steadily with sliding velocity along a smooth curve, and matches very closely the curve obtained from the observed μ for the full scuff points of Figure 68.6, although the difference in slide/roll ratio seems to have modified the value of the coefficient of friction slightly.

The hypothesis will, therefore, explain why these characteristic curves are obtained, a point on which there has been considerable conjecture in the past.

Although much work is required to establish the absolute validity of this suggestion, it is possible to predict that:—

(*a*) only test machines which simultaneously measure μ, P, and V can be successfully used to explore the problem of scuffing and evaluate lubricants.

(*b*) allowance must be made for the variation of μ with slide/roll ratio in these machines and gears.

(*c*) good correlation between these various machines and field results should become possible.

Work is in progress to explore further the validity of the equations and to draw conclusions. This, it is hoped, will form the subject of a future paper, but the views expressed here seem to offer a new way of tackling a very thorny problem which may be of interest to other people working in this field.

Yours faithfully,
L. A. Cooper,
Assistant Manager,
Department for Technical Information.
C. C. Wakefield & Co. Ltd.,
46 Grosvenor Street,
London, W.1.
11 March, 1958.

TYPING MATHEMATICAL MANUSCRIPTS

Sir, A chronic, if minor, irritation in scientific and technical writing is the fact that few typewriters have Greek symbols. These, therefore, must be put in by hand, which is untidy, time-wasting, and involves risk of error.

There is a need, therefore, for a "Graeco-Roman alphabet" in which Greek letters are replaced by typable symbols. These should be easily memorised, easily typed, and avoid risk of confusion with other mathematical or chemical symbols. The following is a tentative suggestion:—

Each Greek letter is represented by the first two Roman letters of its spoken name, underlined. For lower-case Greek the Roman letters are lower-case, for capital Greek they are capital. For example:—

$\pi = \underline{\text{pi}}$	$\Pi = \underline{\text{PI}}$
$\lambda = \underline{\text{la}}$	$\Lambda = \underline{\text{LA}}$
$\phi = \underline{\text{ph}}$	$\Phi = \underline{\text{PH}}$

I do not think that either of these "phi" symbols could easily be confused with pH, the hydrogen ion potential, but if this risk is thought appreciable one could horrify the etymologists by using fi. Omicron and omega would, in this system, both be om, but so far as I know omicron is never used owing to risk of confusion with the Roman O and with zero, and could be dropped.

This system lengthens a mathematical expression, but seems to have no other drawbacks. For example:—

$$\mu/\rho = \alpha \pi r^2 \sin \theta$$

becomes:—

$$\underline{\text{mu}}/\underline{\text{rh}} = \underline{\text{al}}\ \underline{\text{pi}}\ r^2 \sin \underline{\text{th}}$$

It has the advantage of giving mathematicians some extra symbols to play with, since the capitals A, B, E, Z, H, I, K, M, N, P, T, X, common to both Roman and Greek alphabets, can now be distinguished, e.g., Roman A, Greek AL.

One might add to this "alphabet" some other common untypable symbols such as the integration and partial-differential signs, e.g.,

$$\int_0^a F(x)\ dx = \underline{\text{IN}}_0^a\ F(x)\ dx$$

$$\frac{\partial y}{\partial x} = \frac{\underline{\text{pd}}\ y}{\underline{\text{pd}}\ x}$$

I expect some of your readers can suggest improvements, but this may start the ball rolling.

Yours faithfully,
J. F. Alcock,
Chief Scientist.
Ricardo & Co. Engineers (1927) Ltd.
Bridge Works,
Shoreham-by-Sea,
Sussex.
10 March, 1958.

ENGINEERS AND THE GUILD

Sir, In a letter published in your issue of 14 March, Mr. E. H. Bateman criticises the existing scope of membership of the Guild, which he describes as a "parochial attitude in respect of the definition of the professional engineer." Unfortunately there is no general agreement among members of the profession as to where its limits should be set, by reference to particular qualifications, and in the absence of any such agreement it does not follow that what would satisfy your correspondent would be acceptable to engineers in other branches of the profession. My Council believes that the present uncertainty is detrimental to the interests of the profession in that it makes more difficult the task of educating the public about the professional engineer. The following was therefore adopted as the first item in its current programme:

> To establish a definition of the engineering profession; and to bring about the acceptance of this definition by the Government, industry and the public.
>
> To take all possible steps to ensure that professional engineering positions are filled by persons whose qualifications bring them within this definition.

Such a definition must be both practical and generally acceptable if it is to succeed in its purpose, and no doubt the qualifications for membership of the Guild will be reviewed in the light of the definition which is finally adopted. In the meanwhile I hope that none of your readers who may be invited to co-operate in the survey of professional remuneration now being conducted jointly by the Guild and the Royal Commission on Doctors' and Dentists' Remuneration, will withhold their support on doctrinal grounds. The survey will provide comprehensive and reliable information in a form which does not exist at the present time, and this must surely be of benefit to all those who are concerned to further the interests of the profession.

Yours faithfully,
J. G. Orr,
Secretary.
The Engineers' Guild,
78 Buckingham Gate,
S.W.1.
18 March, 1958.

Plant and Equipment

NEW BRITISH CROP-SPRAYING AEROPLANE

One of the most promising export markets for aircraft is in the agricultural field. The 10,000 or so aircraft currently in use throughout the world for aerial spraying and dusting duties are, for the most part, adaptations of surplus military trainers or light aircraft, which, although they are doing excellent work, cannot expect to be as efficient as an aircraft designed specifically for agricultural use. The prospects for the new Auster Workmaster, which has been built to the specification of one of Europe's largest operators of agricultural aircraft, Crop Culture (Aerial) Limited, would therefore seem to be bright. The makers, Auster Aircraft Limited, Rearsby, Leicester, can promise deliveries within 14 weeks; and it is noteworthy that the prototype Workmaster flew successfully in less than three months from the drawing-up of the specification.

So far, 14 Workmasters have been ordered, nine by Crop Culture (Aerial) Limited, Bembridge Airport, Isle of Wight, and five by a French aerial spraying company, Ardic, with whom Crop Culture have been closely associated on spraying contracts in West Africa. Crop Culture, although they have only been in existence for three years, have expanded rapidly from a " fleet " of two converted Tiger Moths in 1955 to over 30 aircraft, in use or on order, to-day. They have had intensive experience in the United Kingdom, the Sudan and West Africa, using several types of adapted standard machines, all of which they found to be below their requirements in " work capacity," which they define as a function of the spray-tank capacity, the aircraft cruising speed and the turn-round time.

Their specification, then, called for a higher-powered engine than those currently in use, and in fact they asked for a 180 h.p. Lycoming engine, which has an exceptionally good power/weight ratio, to be fitted with a constant speed propeller. The required cruising speed was 90 mile/h, instead of the current 75 mile/h, and a spray-tank capacity of 100 gallons was required, in place of the usual 45 gallon tank. On most converted aircraft, the only possible place for the spray tank is behind the pilot—an undesirable feature should the aircraft crash, as the pilot might then be crushed between tank and engine; on the Workmaster, therefore, Crop Culture called for the spray tank to be located alongside the pilot; and for a second seat to be provided behind the pilot—a valuable transport asset in under-developed countries. The aircraft was required to be extremely rugged, and to be fitted with large diameter wheels for ready handling on rough ground.

All these features, then, are incorporated in the Workmaster, which is shown below without its Britten-Norman spraygear. The aircraft is of steel construction. The engine, a 180 h.p. Lycoming O-360-A, drives a McCauley variable-pitch propeller. Complete with spray gear, the all-up weight of the Workmaster is 2,500 lb, and the estimated performance figures at maximum weight are as follows: take-off run, 180 yards; rate of climb, 650 ft/min; economical cruising speed at 65 per cent power, 88 mile/h; fuel consumption at economic cruise, 7·5 gal/h. The wing span is 36 ft, the overall length 23 ft 7 in., the height (tail down) 6 ft 2 in., and the under carriage track 6 ft 2 in.

Additional safety features built into the Workmaster—which will often operate at very low altitude, barely clear of the ground—include the fitting of a jettison valve in the base of the spray tank, enabling the entire contents to be dumped in 5 seconds, thereby increasing the rate of climb from 650 to 1,000 ft/sec. The pilot's seat, designed to withstand 25 *g*, is equipped with a Terylene shoulder harness, resistant to chemical attack. The windscreen is of increased thickness, to resist bird collision; and oversize low-pressure tyres ensure safe taxying over rough or muddy airstrips. Locust guards are provided over the engine air intake and the cabin ventilators.

The Workmaster will be fitted—as are all Crop Culture's aircraft—with the Micronair rotary atomiser, designed and developed by Britten-Norman Limited, Bembridge Airport, an associate company of Crop Culture. (The latter company, in fact, are an offshoot of Britten-Norman established for the purpose of exploiting, in the United Kingdom, the rotary atomiser.) Each aircraft is fitted with two atomisers, one on each wing tip. The spray chemical is fed from the chemical tank in the fuselage to the atomisers through pipes in the wings.

The liquid is then dispersed by the atomisers in minute droplets of concentrated chemical, which results in a much more economical use of fluid than is possible with the earlier system of spanwise fixed spray nozzles. This mist of chemical particles is driven down into the crop by the turbulent air created by the wing-tip vortices. Flying at a height of only a few feet, the spray penetrates the crop thoroughly, thus giving an even cover of the chemical over the entire plant.

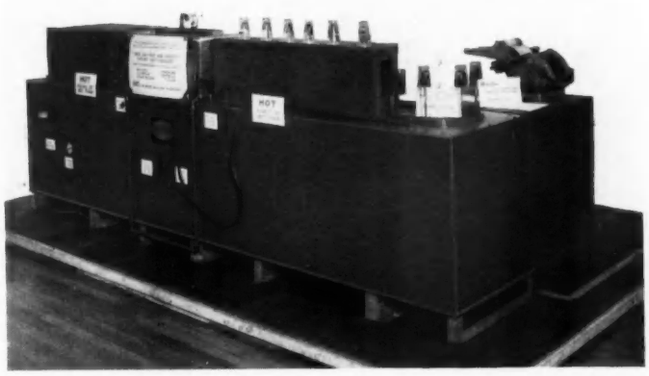
The Auster Workmaster, a crop-spraying aircraft of high work capacity.

GAS FURNACE FOR GLASSWARE

One of the items demonstrated by the South Eastern Gas Board at the Sussex Industries Exhibition was a gas-heated furnace for burning patterns on to glassware. The furnace was manufactured by Stewart Gill and Company Limited, Benlow Works, Silverdale-road, Hayes, Middlesex.

The pattern is first printed on the glass by a printing machine manufactured by Rejafix Limited, 81-83 Fulham High Road, London, S.W.6. This uses standard Zinco engraved positive printing blocks, and during each printing operation the face of the block is automatically inked with a special ceramic burning-in ink. The face of the block is brought into controlled contact with the flat surface of a resilient transfer printing pad, so forming a negative inked impression. The article to be marked, in this case a tumbler, is rotated over this inked impression since it is round in shape, or it would be pressed down over it, if flat. The printed article is then placed on the conveyor which carries it into the furnace.

The furnace is in the form of a tunnel 23½ in. long, 13½ in. high and 11½ in. wide. Two rows of six radiants supported on cast-iron plates and heated by bar burners, are backed by moulded vermiculite; the same material is used to form the roof. Vents in the roof allow the products of combustion to escape. Units can be mounted in line to form tunnel furnaces of any desired length. The particular model demonstrated, operates at a maximum temperature of 1,000° C with a gas consumption of 0·5 therms per hour approximately. For burning-in a temperature of only 600° C is required. Pre-heat and after-heat tunnels are fitted, both of which are heated by the end losses from the furnace and the purpose of which is to eliminate damage to the glass by thermal shock. The conveyor is a chain-operated Carousel unit, running at a speed of 1 ft/min (allowing 90 sec in the heated zone), with jigs at 3 in. intervals. The throughput is 240 components per hour.



Printed patterns can be burnt on to glassware at the rate of 240 items per hour.

Continuing **Plant and Equipment**

RECORDING PHOTOGRAPHS MAGNETICALLY

A new magnetic tape recorder, called the Ampex Faxtape machine, makes it possible to transform a photograph into magnetic impulses that can be transmitted, stored permanently on tape, or converted back to a picture at will. Upon playback the machine "remembers" the original picture without loss of detail.

The picture fed into the Ampex Faxtape recorder is in the form of the output signal from a standard facsimile transmitter. Once on tape, this signal may be sent to other Faxtape machines with a speed several times that of ordinary facsimile transmission.

The picture degradation normally experienced between successive generations of facsimile pictures is largely eliminated with the Ampex machine, according to Mr. J. Jipp, manager of the Instrumentation Division of Ampex Corporation at Redwood City, California. He explained that the Faxtape recorder has a built-in precision time standard, providing playback with a timing accuracy better than two parts in a million. Complete grey-scale fidelity is claimed.

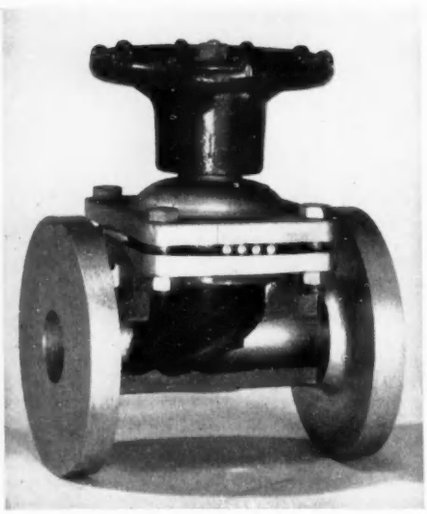
While facsimile processes have long been used by news, weather and overseas radio services, the advent of the Faxtape machine, with its ability to retransmit pictures without loss of values, should result in many new scientific and industrial applications of facsimile. In addition to the Faxtape recorder, Ampex manufactures recorders for capturing "live" TV on tape, for professional and broadcast recording, and for stereophonic sound in the home. The corporation's instrumentation division specialises in machines for recording such data as in-flight missile performance, analogue and digital computer outputs, programme control impulses and other scientific information.

The wire line signal fed to the Faxtape recorder modulates a carrier frequency. The modulated carrier rather than the wire line voltage itself, is recorded on the tape. Thus any amplitude variations in the recorded signal have negligible effect on the amplitudes of the signal reproduced on playback, and inconsistencies in tape coatings do not impair the quality of the reproduced picture.

The Faxtape recorder works normally at 7½ in. per sec. But frequency response up to 20 kc/s at 60 in. per sec. is available for other facsimile-recording systems. At the normal speed a standard reel of tape will record the equivalent of seven 7 in. by 9 in. news photographs scanned at 100 lines per in., plus their associated "one minute of white" and audio instructions. No "make ready" is required between pictures. Once started, the recorder will run unattended throughout the whole reel of tape (about 1 hour).

Magnetic tape device for storing and reproducing pictures indefinitely.

GLANDLESS STOP VALVE

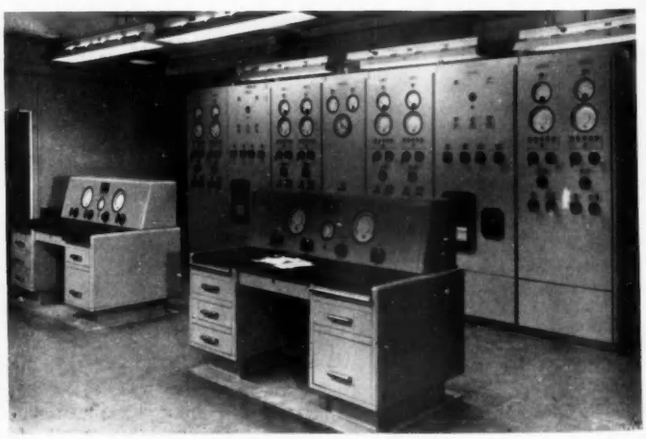


The Meynell "Rayon-Patent" stop valve has only one part in contact with the fluid being controlled.

Introduced by Meynell and Sons Limited, Montrose Street, Wolverhampton, the "Rayon-Patent" stop valve has a rubber "clack" so shaped that only the under surface of the rubber is in contact with the fluid being controlled; as the moving parts of the valve are isolated, no packing glands are required. The rubber fits into a formed depression in the valve body, so ensuring a perfect seal when the valve is closed. There is a clear, unrestricted passage when the valve is open, and pressure losses, as a result, are negligible. Open and shut positions are clearly indicated, and the valve can also be used in any intermediate position for regulating fluid flow, without danger of rapid wear. Long life and low maintenance costs are ensured by the simplicity of the design, and the fact that only one part, the rubber, is in contact with the fluid.

A range of valves is in production from ¼ in. to 6 in. diameter, with either British Standard pipe thread connections or flanged ends as required. Non-shock working pressures range from 220 lb/sq. in. to 65 lb/sq. in., according to the size of valve. Normal production is of valves with cast iron bodies, the rubber part being made of a suitable natural or synthetic material, according to the fluid being controlled. Nylon can also be supplied in place of rubber, where the latter is not suitable. A hard rubber lining is available for the cast iron bodied valves. Alternatively, the body can be of bronze, zinc-free bronze, aluminium, or lead, or plastic lined.

HIGH POWER GERMANIUM RECTIFIER



Two rectifier equipments, each of four units, feed direct current to two electrolytic cell lines for the production of chlorine. The control room is shown alongside.

An 18,400 kW rectifier set has been installed at the Ellesmere Port plant of Associated Ethyl Company Limited. Germanium power rectifiers are used and the equipment was installed by the British Thomson-Houston Company Limited, Rugby. The rectifiers supply a direct current of 80,000 amperes to two electrolytic cell lines for the production of chlorine.

Two equipments, each of four units, are installed. Each unit is complete with its own transformer and associated switchgear and operates at 230 volts. The rectifiers are connected in a three-phase bridge circuit with phase-shift transformers to give an effective 48 phase operation. The output of each unit is controlled by means of an auto-connected regulating transformer equipped with 17 position on-load tap-changing gear and a trimming regulator to give fine control between tappings. The induction-type trimmer is excited from a tertiary winding of the regulating transformer and feeds back into a series-boost transformer connected between the regulating and rectifier transformer primary winding.

The regulating, series-boost, and rectifier transformers are combined in one unit. In each cell line one master Selsyn transmitter controls the Selsyn receivers which drive the induction regulators. When, during the regulation process, the induction regulators reach the end of their travel, a transformer tap change is initiated. In addition all four units are resynchronised to ensure that correct load sharing is maintained. Both equipments are controlled from desks in a central control room, which houses the metering, incoming, and alarm panels.

The rectifier unit is divided into three cubicles, each holding six trays of germanium cells. The cells are connected in a series parallel arrangement. Almost all the loss in the rectifier cell occurs during forward conduction and corresponds to a voltage drop of 0·5 volt per cell. The total efficiency of the rectifier, main and regulating transformers, trimmers and phase shifters, at normal load, exceeds 96 per cent.

ELECTRICITY ON SHOW

On March 25 the Electrical Engineers Exhibition will open at Earls Court, London. Once again the organisers can say that it will be the largest yet (each one has been that so far) but this year they can add that it is now one of the largest industrial exhibitions to be held in this country. There are about 400 exhibitors and the stands cover an area of 450,000 sq. ft. The exhibits themselves range in size from a 27 ton fan motor (too large to be taken inside the building) to a transformer the size of a wedding ring.

Each year the exhibition has a theme. Once it was motors, last year educational and this year the central feature is "Electricity in Hospitals." However, the educational and career stand is to be repeated—a wise move in view of the continuing need for engineers and technicians of all grades. "Mr. Pylon" who stood in the forecourt last year will regard the scene from the backcloth in the hall; flashing lights have been arranged to give the impression of a turning head. Items that cannot easily be missed are the slotted angle staircases leading to the gallery; free-standing, they are 35 ft high and have a stairway 5 ft wide. There are four intermediate platforms about 100 sq. ft in area, which will be timber floored; wood will also be used for the treads and handrails. Nearly seven tons of metal will be incorporated in the installation.

STEPLESS STARTER

Lee Guinness Limited, Newtownards, Northern Ireland, are to show an automatic device for starting slip-ring motors made under licence from A.LO.P.-Bérard. It makes use of the principle that the vapour of an electrolyte has a greater resistance than the liquid phase. In its simplest form the apparatus consists of two electrodes opposite each other in a small chamber of insulating material. This chamber is submerged in a tank of electrolyte with which it communicates by orifices designed to give a calculated resistance to the flow of liquid.

When a high current is passed between the electrodes the intense local heat causes the liquid to vaporise within the chamber, which therefore becomes filled with vapour and so offers an increased resistance. The orifices prevent the immediate replacement of the vapour by more liquid. As the current passing falls, the vapour tends to condense and the liquid to enter the chamber, with the result that the resistance decreases. A stepless variation of the resistance is thus obtained from a maximum to a minimum.

A cut-away view of one of the Vapormatic starters is given in Fig. 1 and a diagram of connections in Fig. 2. The action is somewhat similar to that of a star-delta starter in that the electrolyte forms the resistance between the rotor leads and a star point, and a shorting contactor forms a delta connection when the resistance has fallen (i.e., the rotor has speeded up). The shorting contactor can be operated either by a thermistor or by a timing relay as desired.

In the cut-away view the three electrodes can be seen entering the chamber. Within, they form three compartments of equal size each of which contains one point of the star connection. The orifices which connect with the main tank can also be seen. The delta contactor is mounted above.

Only one size of starter is made, suitable for motors up to 40 h.p.: two or more units can be connected in parallel for operating higher powers than this. A wide range of starting conditions can be catered for by adjustment of the electrode chamber volume. The unit measures 18 in. high by 9 in. in diameter.

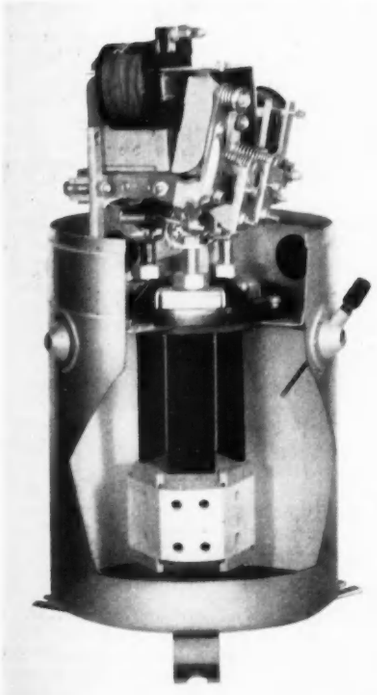


Fig. 1 Cut-away view of the Vapormatic stepless starter for slip-ring motors.

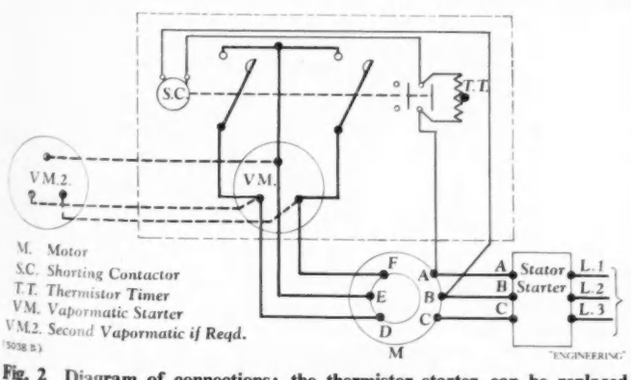


Fig. 2 Diagram of connections; the thermistor starter can be replaced by a timing relay if desired.

IMPEDANCE TESTER

The instrument department of Ferranti, Limited, is showing several models. Among them is an impedance tester for use in checking the installations in buildings. It works on the phase-earth loop principle and momentarily puts an actual fault from line to earth. The current is broken in 1½ cycles by two miniature circuit breakers. If the loop impedance is low enough to permit the passage of a fault current greater than the fuse rating marked on the shunt selector switch, then a cold cathode valve glows continuously till reset. A voltmeter can be used to check the polarity of the supply.

DISTURBANCE RECORDER

Another instrument to be shown by the same firm is a disturbance recorder. It consists of an oscillograph chart recorder with seven oscillograph traces and twelve d.c. marker traces which are made continuously on a drum but only transferred to paper on the receipt of a signal. A memory feature causes the chart to record the conditions from about 0·5 s before the signal is received; the chart speed is approximately 6 in./s. The chart can be handled immediately, the markings are permanent and one inking will last for a year.

Fig. 3 Selector panel for programme controller.

PROGRAMME CONTROL

Heenan and Froude Limited, Worcester, are showing examples of their Dynamatic couplings and dynamometers. Also there will be a Heenatone programme control unit designed for a repeated cycle of operations. The selector is illustrated in Fig. 3. Unusual among such units, it employs tones of various frequencies recorded on magnetic tape. The record is then played through an electronic frequency analyser which identifies the tones and operates corresponding contactors. The programme can be recorded from actual working conditions or synthesised before-hand. The tones are produced from a frequency generator and selected by push-buttons.

MICRO-SWITCH

Burgess Products Company, Limited, Dukes Way, Team Valley, Gateshead 11, are to show a full range of their micro-switches including the new V3 miniature model. Externally this resembles closely the existing Switchette but the mechanism has been redesigned to give a high speed performance and a minimum life of ten million operations. In addition to the standard model there are two variants, one offering reduced operating force and the other reduced movement differential. The standard model fitted with a frictionless pivoted actuator is shown in Fig. 4. The long lever reduces the force needed for the standard model to one oz maximum and for the V3/2 to ¼ oz. The switches are to be shown operating 2,000 times per minute.

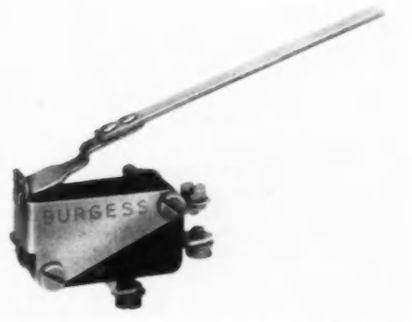


Fig. 4 Only ¼ oz is needed to operate the switch.

Continuing **Electricity on Show**

COBALT THERAPY

One of the most recent cobalt therapy units, and one which can be used for both stationary and moving field techniques, is the Newton Victor " Orbitron " manufactured by the Metropolitan-Vickers Electrical Company Limited, Trafford Park, Manchester 17. One unit has been installed at Cardiff and a second is destined for Ravenna. A quarter-scale model is to be shown in the " Electricity in Hospitals " section of the seventh Electrical Engineer's Exhibition at Earls Court, London.

The design of the Orbitron has been evolved by close collaboration between the medical and physical staff of the South Wales and Monmouthshire Radiotherapy Service, Cardiff, and Newton Victor engineers. It consists essentially of a protective container to house the radioactive cobalt and confine the radiation to one beam, an annulus to which the container is attached so that it can be rotated about the patient, and a treatment table.

The radioactive cobalt source is housed in a protective container in the form of two merged spheres 23 and 14 in. (58·42 and 35·56 cm) in diameter, respectively. Sufficient space is provided to house a source up to 2 cm diameter by 3 cm long. The lead and heavy-metal protection is sufficiently thick to reduce the radiation to the values given below when a total of 2,000 curies is housed in the container. Self-absorption reduces the output of radiation so that the effective value of the source is about 1,500 curies. A section is shown in Fig. 6.

The cylindrical source is secured in a recess at the periphery of a protective disc which rotates in a plane at 90° to the beam axis. When not in use the source is at the centre of the larger sphere in what is termed the " protected " position. For treatment, the disc is rotated through 180°, bringing the source to the centre of the smaller sphere and opposite the radiation port in what is termed the " treatment " position.

In the " protected " position the protective material surrounding the source is sufficient to reduce the radiation to less than $6{\cdot}25 \times 10^{-3}$ r per hour at a distance of 5 cm from the outer surface of the sphere. In the " treatment " position the protective material is sufficient to reduce the radiation to 2×10^{-3} r per second (7·2 r per hour) at a distance of 5 cm from the outer surface of the smaller sphere or beam diaphragm.

The source is driven by a motor from the " protected " to the " treatment " position in a period of two seconds through an arc on the support side of the container, and on completion of the treatment it is returned to the " protected " position by means of springs. The motor is energised during treatment and holds the source in the " treatment " position against stops. The absence of any electrical contacts or switches ensures that the source is always accurately centred with respect to the beam diaphragm. Any failure of the motor or the electricity supply will free the source so that the springs return it to the " protected " position. As a further safeguard, the source can be returned to the " protected " position manually without removing any parts or disengaging any gears. A luminous indicator on the container shows the position of the source even in the absence of any electricity supply.

The beam diaphragm fitted on the container has been dimensioned to permit rotational therapy at a source-to-axis distance of 75 cm. The heavy-metal blocks defining the beam are partially housed within the smaller sphere of the container and the whole assembly is less than 35 cm from the source. The tungsten-alloy beam diaphragms are constructed to move in arcs centred at the source of radiation so that the faces of the diaphragms are always parallel with the sides of the beam. Each pair of diaphragms are coupled together and adjusted by one knob against a scale showing the field size at 50 cm and 75 cm. The radiation port limits the beam to 30 cm diameter at 75 cm while the minimum width of beam is 2 cm.

All square fields between 2 cm and 21 cm and all rectangular fields with diagonals not exceeding 30 cm can be employed. The entire beam diaphragm system can be rotated on the beam centre line for stationary field work. With the source in the " protected " position, the field can be illuminated by a light housed inside the container.

The supporting stand is in the form of an annulus rotating in a yoke. The container is mounted on a trunnion which allows the beam to be tilted from 30° inwards up to 90° outwards. In addition, the radius of rotation is adjustable between 65 cm and 75 cm. Rotational speed is variable from $\frac{1}{8}$ rev/min to $\frac{1}{2}$ rev/min (stabilised to within $2\frac{1}{2}$ per cent) with an extra speed of 1 rev/min for setting up. All movements can be controlled either locally or from the control room.

Several movements can be set up by the use of arc selector arms and switches. The container can be rotated continuously about the horizontal axis; the beam can be interrupted over any selected arc; or the container can oscillate over a chosen arc. Projecting bumper bars stop the movement and return the source to the " protected " position if patient or table obstruct the path of the container. A treatment timer, with a range from 1 sec to 55 minutes in steps of 1 sec, starts to operate as soon as the source reaches the " treatment " position, and returns it to the " protected " position on the expiry of the chosen period.

Fig. 5 (right) For cobalt therapy, the container can be made to rotate round the patient, with or without interruption of the beam, or to oscillate over a chosen arc.

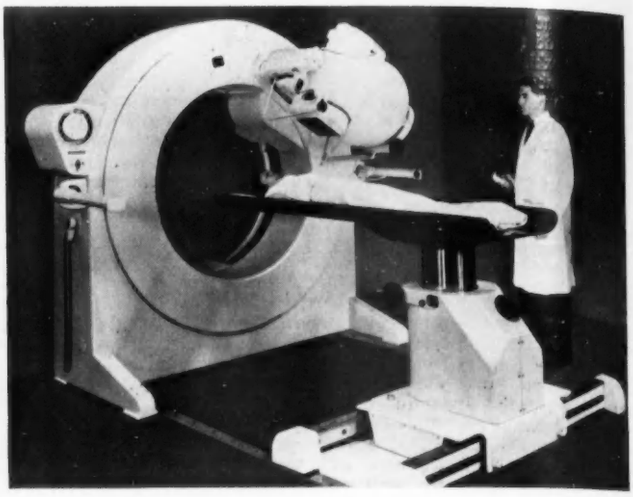
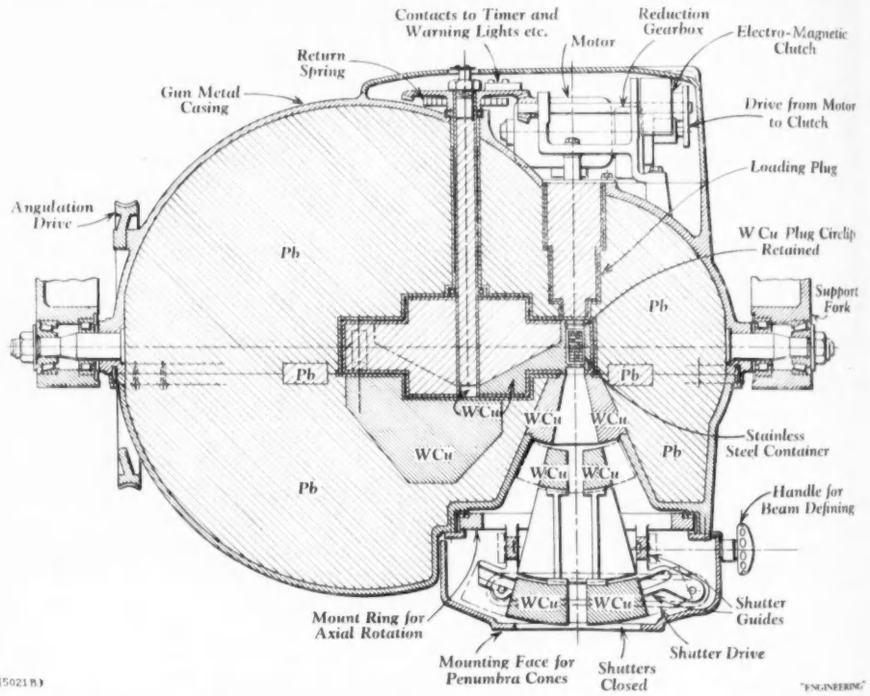


Fig. 6 (below) The source container includes the mechanism for moving the source to and from the treatment position, and adjustable shutters to define the beam.



FACTORY DISTRIBUTION

In order to show as much as possible of their ranges, the General Electric Company Limited, have arranged their stand to represent the distribution system of a factory. One section is an 11kV substation with a T-off ring main circuit-breaker, a transformer and airbreak medium-voltage switchgear. Local supplies are distributed through switch boards and trunking to lights, heaters and motors. In the canteen section are ovens, and the manager's office is complete with air conditioning, staff locator and indicator alarm systems. The second of the company's stands is devoted to lights and lighting fittings.

The Human Element

Prescription for Unemployment

Unemployment in the United States rose by 600,000 in February to reach the highest level since the war, some 5·2 million. The problem of keeping this huge number adequately fed and housed is difficult even for the wealthiest country in the world. Not all are eligible for unemployment benefit—only about 3 million of those who are out of work—and the benefit cover is limited, to an average of 26 weeks. President Eisenhower quickly announced his decision to ask Congress to extend the payment of unemployment benefits to those who have already used them up and are still out of work, and a 13 week extension now seems likely. This will cost the country about 1,200 million dol., but will stave off industrial unrest and, by keeping up some of the purchasing power of the unemployed, prevent the recession from feeding upon itself as was the case in 1930.

The level of payments varies widely from state to state, from 25 dol. a week in Louisiana to 57 dol. a week in Nevada. The average is at present 27 dol. a week, or one-third of the average weekly wage paid by manufacturing industry. There has been a tendency in recent years for industry to draw up agreements with the trade unions for the payment of a substantial proportion of the weekly wage—60 per cent in the case of the motor industry for six months, and 65 per cent in the case of the steel industry for a whole year. In such cases it can pay a worker to be wholly unemployed rather than be on short-time. But such agreements are limited to 4 million out of 43 million who are entitled to unemployment benefits. A further 23 million are not covered by unemployment insurance schemes and get nothing.

There is little doubt that further considerable pressure will be put on American industry to give greater security to the weekly wage earner. If this goes far enough, and if industry can save enough to finance these vast schemes, the United States may have gone a long way towards the control of trade recessions.

Treatment for Tender Spots

There were last month more than two unemployed for every vacancy in the country as a whole and in some areas the proportion was much greater. In Scotland and Wales, for example, there were as many as six unemployed for every vacancy and in Northern Ireland unemployment topped 10 per cent of the working population.

The Government clearly share the concern felt by M.P.'s on both sides of the House on account of the growth of unemployment in some areas. Even if the country as a whole was in the best of economic health, the local soft spots could not be ignored without serious political repercussions on the party in power.

It is difficult to see what the Government can hope to achieve in the short term by localised action. Long-term planning of the location of industry can, and to a limited extent already has, given the development areas their share of growth industries. But this takes many years. To reverse the trend now would require a return to a policy of expansion at all costs—and one of these is inflation.

Towards a New Peace

Human relations in industry were the subject of a detailed and interesting review by Mr. D. M. Sinclair, general manager of the Birmingham and Midland Motor Omnibus Company Limited, in a paper read to the Institute of Transport last week. Quoting Mr. Aneurin Bevan's statement to an American audience that "traditional methods cannot work any more. The only alternative to fighting is co-operation and negotiation," Mr. Sinclair put down as a condition for good relations in industry that the people engaged in it, "from the top to the bottom" should be imbued with "a strong pride in the achievements of our people and a faith in their future." His plea was for a new kind of industrial patriotism, aimed at placing the country on the economic map, and unmarred by internal fighting.

This kind of approach is needed. Too much of current thinking is conditioned by the continuous talk of "both sides of the industry." The social trends of the past decade have led to a greater communion of the interests of the managers and the managed than ever before. In the new age—"this extraordinary, atomic, ballistic, and satellite age"—Mr. Sinclair is doubtful if a place can remain for sectional interests.

The latter part of the paper dealt with the means available to achieve this unity. There, Mr. Sinclair was unable to point to any new way, advising frankness, better communities, round (as opposed to rectangular) conferences, independent arbitration when disputes do occur (tribunals being required to give the full reasons for their decisions), better training of supervisors, and other methods already in use. There can, of course, be no short cut to real understanding, except in a frightful emergency—a war or a slump—when all are threatened and all must suffer.

Contentment Pays

An article called "A Theoretical Setting for the Study and Treatment of Strikes" in the current issue of *Occupational Psychology* discusses the causes of industrial unrest and makes a plea for more research into the subject. Dr. E. P. Kelsall, the author of the article, points out that co-operation to improve the contentment of people in their work would pay off in money as well as indirectly.

The article analyses the reasons for antagonisms, conflict and suspicion in industry. Many without first-hand experience will find the examination of the cross-currents in human relations exceedingly valuable. The sources of friction within trade-union organisations, the different approach of trade-union organiser, shop steward and union member, and the way these frictions are exacerbated by the process of bargaining with management are complicated but live issues. It is well to be reminded that good labour relations are not established by a simple effort to improve direct relations with the operatives' representatives. Management must play an active role in maintaining good channels of communication with labour, encouraging the men's leaders to use their energies in constructive ways which do not conflict with their loyalties, so avoiding a sense of frustration. In short, a good personnel manager, like a good general, maintains an intelligent initiative.

Variety of Precedents

The award of the equivalent of 4½ per cent to the bus workers on the Central London routes of the London Transport Executive has pleased no one. The L.T.E. probably expected a smaller award and will not relish the quick injunction from the Minister of Transport to pay for any increase out of economies. The workers are annoyed that the scope of the award is so limited. The thinking public are left wondering if the award is accepted by both sides, how big a wedge has been driven into the deflationary policy of the Government.

A variety of precedents will be read into the pecision of the tribunal. The likeliest one is that a level of 4½ per cent has been set which is above that thought desirable by the Cohen Council. Others will say that since the decision only restores a differential (and this is the real worrying issue for the union) no precedent has been set at all. The sophisticated can say that since the increase is to be paid for (in effect) by economies, which mean cutting schedules, it is hastening a process which is economically desirable anyway and that this industry is a contracting one and merits special and stiff medicine. If the union is prepared to be unwittingly the means of supplying it, why worry?

We can take our choice from all these and a number of variants arising from them. The first interpretation is the likely one to stick since a large number of people have a pecuniary interest in seeing that it does.

Filter for Careers

The country's efforts to give the educational bulge the best it can have is beginning to look impressive. Granted there is a shortage of good school accommodation and teachers are scarce in many places, the problem of how to train the young and where to encourage them to find a career is absorbing a good deal of attention and producing a good deal of constructive thought.

One of the latest signs of all this is the 1958 edition of the National Union of Teachers *Annual Guide to Careers for Young People*. Some 20,000 copies of the guide are being distributed throughout the educational network. It is intended to assist those with responsibility for advising school leavers on their careers. This issue follows one in July 1957 which met with a considerable response. Although the booklet is issued only on a limited scale to schools a number of copies are now on sale, price 3*s*. post free from the N.U.T.

No system of advice to the young can prevent fairly large numbers drifting into unsuitable jobs but it can do a valuable service for the good and the mediocre. Many people drift into jobs because of a family pattern, lack of knowledge of what a wide choice of jobs they may be qualified to do, and sheer romantic illusion. Informed advice can help to offset the undue influence of the first two of these but it cannot do much about the third. No book or teacher will cure the thoroughly stage-struck or the ham-fisted youngster who wants to be a great surgeon. It will probably be a bad day for the nation when it can.

Fatal Class Distinctions

While the experts are busy scaring business executives stiff about their liability to coronary thrombosis, the Registrar-General's *Decennial Supplement, England and Wales* 1951, *Occupational Mortality Part II* shows that the relation of mortality to occupation is a most complicated affair. The figures indicate that mortality is lowest among the managerial classes and highest among unskilled workers.

The statistics do show, it is true, that certain diseases are more common in some kinds of occupation than in others but the business man who has been frightened that he might contract thrombosis has at least the consolation that his chances of dying from it are smaller than his likelihood of dying from pneumonia if he were a navvy.

One point of interest is that the mortality rates in different categories of occupation have changed over the last 30 years. Thirty years ago the lowest mortality rates were for professional men, followed by managerial grades, skilled workers, semi-skilled and unskilled in that order. Managerial and skilled have moved up and professional men have moved down. This is one set of figures which throws interesting light on the trend towards a levelling of incomes and the urge for security among high income earners. Suicide is commonest among professional men.

Special Article

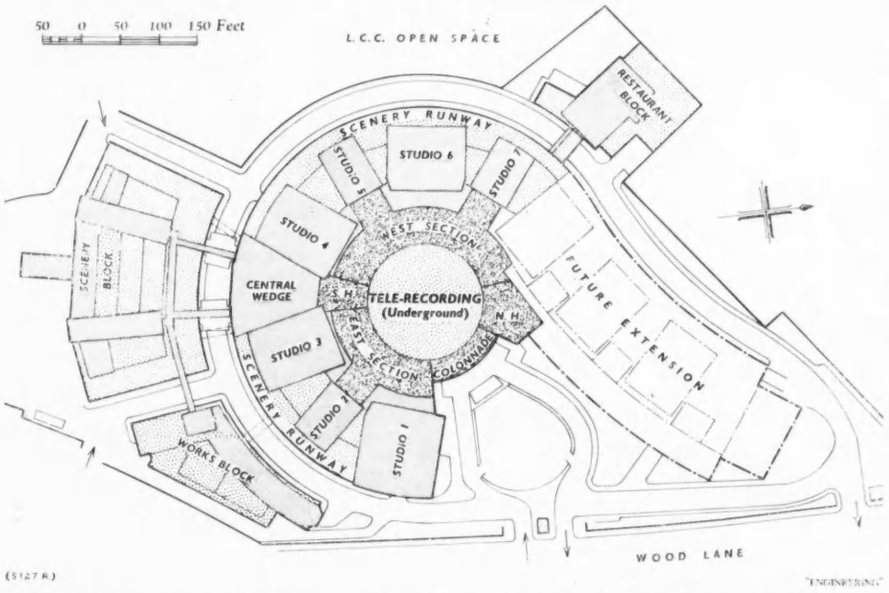
BUILDING ROUND A FLOWLINE

B.B.C. Television Centre

The B.B.C.'s Television Centre will be the largest of its kind in Europe. Standing on a 13 acre site at Wood Lane, West London, it will comprise seven studios and several hundred offices; other blocks will provide facilities for making and storing scenery and "props," a restaurant, and works maintenance. Part of the Centre, the scenery block, is already being used; more will be brought into use as it is finished and the first studio is expected to be commissioned some time in 1961. The project, including equipment, is expected to cost around £9 million spread over 11 years of planning and construction.

The layout and appearance of the Centre is illustrated on this page, except that nothing is firmly known about the extension. Some idea of how far the construction of the main block has advanced is given by the photograph on the opposite page: the framing is virtually complete, much of the cladding and interior walls has yet to be built and installation of equipment has not yet been begun.

Though the restricted site has to some extent determined the layout of the Centre, the arrangement also satisfies the concept that persons (artists, producers, technicians) and goods (scenery, properties, equipment) should not meet except at the point of production, the studio. Thus people will enter the studios from the inner ring of offices and suites while goods will reach the studios from the outside ring of the scenery runway.



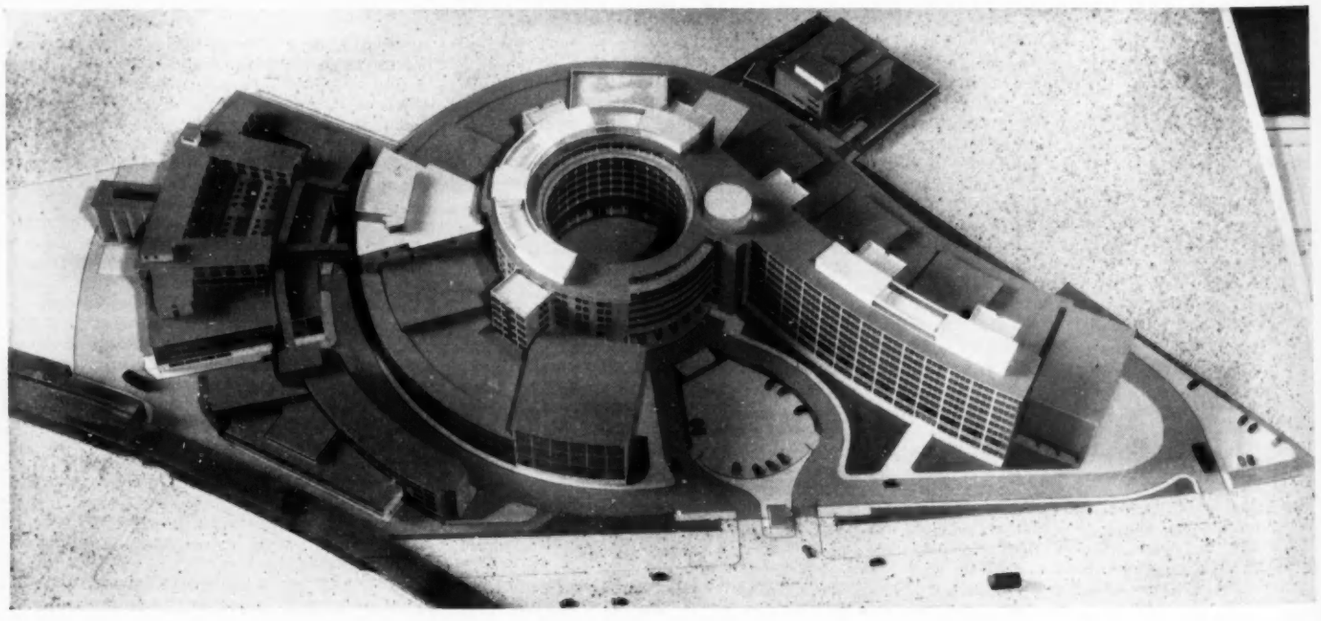
The B.B.C.'s new Television Centre in London has been designed specifically for the production of television programmes. Four of the seven studios are larger than any yet available in the country and all the studios have facilities for colour. The layout is based on the concept that people (artists, producers, technicians) and goods (scenery, properties, equipment) should not meet except at the production point, the studio.

The Centre is the first of its kind in the United Kingdom to be planned and built for the express purpose of producing television programmes. Its capacity is such that the B.B.C. will be able to produce there all the programmes required to meet their present quota of transmitting hours. (Rehearsals will necessarily be undertaken elsewhere, but no centre could conceivably provide the space that would enable this preliminary work to be done under the same roof.) Provision is being made for the adoption of colour television, but in general—so far as studio design is concerned—this only requires the installation of more lighting, and superior ventilation, than is now used for black and white programmes.

Seven studios are being built, four of which will be larger than any now available in the United Kingdom. One will be the largest in Europe. Each studio will have its own air conditioning plant. Studios 2, 3, 4 and 5 will comprise the first operational unit which will come into use during 1961. Orders have been placed for 30 of the most advanced camera channels to be had (a camera channel, besides the camera, includes all the supporting equipment).

The largest of the studios, No. 1, is 108 ft by 100 ft by 54 ft high. It will have a pit, 7 ft 6 in. deep, into which part of the floor—an area of 50 ft by 30 ft—can be lowered; when necessary, the pit will be filled with water. The floor is designed for loads due to double-decker buses and "a line of elephants each with its forelegs resting on the hindquarters of the beast in front." Intended for "light entertainment" and musical programmes, this studio will have accommodation for an audience of 600. The smallest studio, for "talks," is 70 ft by 50 ft by 33 ft.

On the ground floor and in the basement there will be about 120 dressing rooms with accommodation for some 550 artists. These rooms are all arranged around or under the central ring and entry is therefore through doors



at the inner ends of the studios. At their outer ends the studios are linked by a covered runway 20 ft wide. This will be used to convey properties and scenery from the scenery block to the studios; between the studios are rooms for the temporary storage of equipment and "props."

The first and second floors of the inner ring contain the control rooms, one to each studio. The four-storey central wedge, on the southern side of the block, houses technical services at all levels. There will be the telecine (for providing film inserts required for programmes), two presentation suites, and the central apparatus room. The basic elements and functions of a presentation suite are twofold. First there is the presentation studio, with its associated control area, from where the announcements and other small items originate. Secondly there is a central control room which serves as a focal point to which are fed all programme items from studios within the centre, received from elsewhere, including Outside Broadcasting points, regional studios, and all incoming or outgoing Eurovision programmes. From this control room, the necessary switching and mixing facilities are provided to enable the complete television programme to be built up for distribution over the national network. Under existing arrangements only one presentation suite will have to be furnished; if it is decided that the B.B.C. should put out a second programme, then the other suite will also have to be fitted out.

Above the third floor of the ring much of the space will be used for offices, libraries, wardrobes and so on. The scenery block was completed in 1953 and is already in full use serving the B.B.C.'s existing London studios. It includes workshops for making scenery and stage sets, a studio (on two floors) for painting back-cloths, storage space and some 200 offices. Within the basement of this block are the boiler house and the main electrical sub-station, both sufficient to serve the whole Centre. The restaurant block has been in temporary use since 1953 as a rehearsal block and as offices but it is about to be converted to its proper purpose when it will provide service for 750 diners at one sitting. The works block will be undertaken later.

Also in the basement of the main block will be a private automatic telephone exchange (below studio 1) and other areas have been allocated for equipment which will enable television programmes to be recorded for subsequent re-transmission.

The main building has an interesting planform of a question mark, and the architectural treatment both outside and within are pleasingly modern. From a planning point of view the structure is most complex, and provision has been made for an almost unprecedented system of services for which a comprehensive system of sub-floor passages and wall ducts have been built. Once the position of the frame members was settled their design was along conventional lines to established standards. The inner ring of buildings is based on a steel frame with deep-ribbed concrete floors. Somewhat surprisingly for these days, most of the concrete has been placed in situ by pumping and little use has been made of pre-cast sections. Part of the explanation of this is the small number of repetitions of any one member that occur because of the curved form of the structure; nevertheless, it would seem that there would have been advantages to be had in selecting standard sections to pre-cast and then undertaking the easy matter of varying the length of members as necessary. Much of the cladding, the large walls of the studios and runway, are to be of facing brick. On the central courtyard and for the entrance colonnade, mosaics and glass will be used to give colour.

The contractors have experienced some difficulty in maintaining the alignment of the steelwork until the floors had been poured, involving the extensive use of guys. This difficulty has been attributed to the high circular form of the building with the consequent problem of correctly fixing the columns on their bases. Another clue to the cause of this erection problem might be found in the fact that all compound stanchions were welded, so that they may well have possessed some initial curvature.

The foundations conditions were by no means simple. The site is located above a layer of fill—clay, brick-earth, ashes—varying between 15 ft and 20 ft in depth overlying a bed of sandy gravel averaging 10 ft thick and overlying blue London clay. The standing water level is roughly at the top of the layer of gravel. Due to the poor condition of the top fill the foundations have been taken into the gravel bed, but the lower floors have been kept above the water level. During the placing of the foundations—constructed under a separate contract, so that the building contractor started on a clean site—a certain amount of de-watering was required, for which agricultural drains proved sufficient. Both pad and raft foundations have been used in an effort to keep the ground loading constant.

Progress on the Centre, one of the most complicated buildings ever erected in the London County Council area, is well advanced, the frame being virtually complete. The two tower cranes have contributed substantially to the erection programme.

Where large changes in bearing pressures occur, such as at the junction between the office ring and the centre court, an articulated slab has been used to take up differential settlements. The basement was tanked in asphalt and changes in level of the underside of the foundations were kept to a minimum.

Much of the building contractor's principal plant is electrically operated. Bulk concrete is mixed in one of two batching plants, each of which comprises sand and ballast hoppers, a 20 ton cement silo and an electric mixer. Each plant has its own boiler unit with storage tanks and steam lines, so that work can continue in cold weather. The concrete is distributed from these batching plants by pneumatic placers which employ compressed air to force the concrete up steel pipelines to the points where it is to be placed. The central batching plants are supplemented by twelve auxiliary mobile mixers.

Two mobile tower cranes are in use. A Jules Weitz crane located in the centre of the building; it has a capacity of 3½ tons at 98 ft radius and an effective lifting height of 120 ft. There is also a 1 ton Build-master working round the perimeter. Materials are distributed by Monorails, platform and mobile hoists, diesel dumpers and two fully mobile cranes, a 3 ton Jones and a 19 R.B.

From the initial inception of the scheme, close collaboration has been maintained with the L.C.C. in respect of fire precautions. The whole building is covered by a general alarm signal system and emergency lighting is provided on all escape staircases and routes. A sprinkler system has been installed to cover the basement, ground and third floors. Hose reels and wet risers serving floor hydrants are located at each main staircase and in each studio. Electrical sub-stations are fitted with automatic CO_2 distributors, and technical equipment areas are protected by rise-in-temperature indicators. The integration of the fire precautions into the planning and service arrangements has posed considerable problems; the additional cost of steel shutters, fire dampers, secondary lighting, extra wall thicknesses and double walls (which have also served to give sound and thermal insulation and provided joints permitting differential shrinkage and settlement) are together a considerable part of the total budget for the building.

Among the other services to be installed in the main building is a comprehensive vacuum cleaning system. A central cleaning plant in the basement will collect from plug-in points fitted in the skirtings at all floor levels. The principal lifts, a group of four with travelling of 500 ft per min and answering calls as required, are to be installed in the main entrance hall. Two more passenger lifts, with speeds of 300 ft per min, will be in the south hall, and goods and service lifts will be fixed in various parts of the building. Two escalators, 3 ft 4 in. wide, are also to be installed, leading from the main entrance hall to the basement.

The consulting civil engineer to the B.B.C., who has advised on the project, is Mr. M. T. Tudsbery, C.B.E., M.I.C.E.; the architect for the work is Mr. Graham Dawbarn, C.B.E., F.R.I.B.A.; Sir Howard Robertson, PP.R.I.B.A., and Sir William Holford, F.R.I.B.A., are retained as architectural consultants for the scheme.

The contractors for the foundations were George Wimpey and Company, Limited, and the principal building contractors are Higgs and Hill Limited; the sub-contractors for the structural steelwork are T. C. Jones and Company, Limited.

Atomic Review

Ready for the Day

REACTOR development proceeds at such a pace that each stage must be started before its predecessor is complete. There is thus an overlapping of phases, as was shown in Atomic Review last March 7. In particular, though general design work must be finished before a tender can be submitted, detailed development studies may continue long after construction of the plant has begun. Indeed, the objective is to phase work in such a way that each item is ready by the time it is required, so that the available research resources are employed to best effect in terms of the time scale. The General Electric Company, who with Simon-Carves Limited are engaged in building the Hunterston nuclear power station, have recently extended the research and development facilities of their Atomic Energy Division at Erith, Kent, where new laboratories have been established and new equipment installed. G.E.C. are also building the zero-energy high-temperature gas-cooled reactor (HTGC) at Winfrith Heath. They are therefore also likely to be ready for the day when this promising reactor system becomes a commercial proposition.

G.E.C. Extends its Atomic Research Facilities

The new facilities of the G.E.C. Atomic Energy Division are largely concerned with detailed experimental investigations aimed at improving the original design of gas-cooled, graphite-moderated reactors with a view to increasing efficiency and reducing costs, and adapting it to meet special requirements, particularly for the overseas market. Among the new facilities is a laboratory specially designed and equipped for work on beryllium—a metal which is likely to be of considerable importance in the design of advanced nuclear reactors. It shows particular promise as a material for fuel cans and its use for this purpose may permit operating temperature of about 600° C. Other new facilities include a remotely controlled power manipulator, to be described in a subsequent issue, and a laboratory mainly concerned with mechanical engineering problems. The same building also houses a new laboratory for experimental structural analysis. Additional administrative, design and drawing office accommodation has been built to house the increased number of staff, now totalling 450 compared with the 200 members of the Atomic Energy Division less than two years ago.

The heat laboratory of the G.E.C. Atomic Energy Division has been previously treated in Atomic Review (31 Aug. '56 and 20 Dec. '57). Recent research includes flow studies on fuel cans and heat-exchanger tubes using water carrying small particles of polystyrene as markers; heat-transfer tests with a new wind tunnel installed alongside an original tunnel; and experiments on a full-size model of a reactor standpipe. Standpipes provide access to the core for the control rods, and the model is equipped to give conditions of gas, temperature and pressure corresponding to those during reactor operation. There is also a structural laboratory concerned, for example, with investigating the support grid for the reactor core using three-dimensional analysis, and the stress distribution in reactor pressure vessels by means of Perspex models and electrical strain gauges. Photoelastic methods are also to be used.

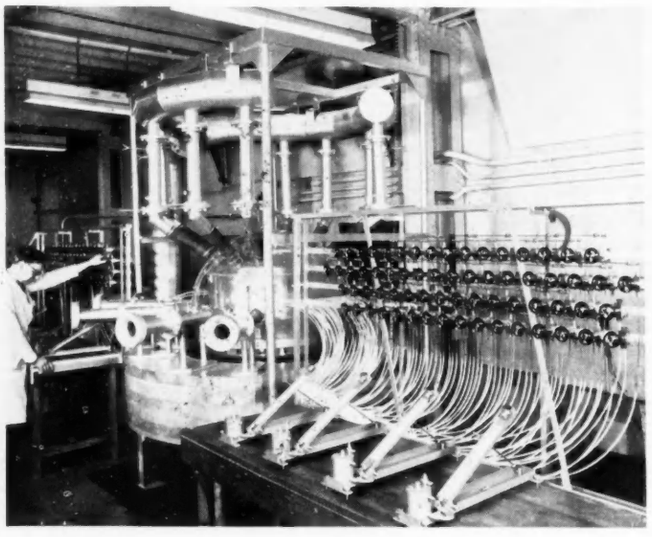
Beryllium Laboratory

At Erith a new laboratory has been established entirely devoted to research work on the metallurgy and technology of beryllium. This metal is of considerable interest to the designer of advanced types of nuclear reactor, and shows particular promise as a possible fuel-canning material. It possesses, however, certain toxic properties which make it necessary to adopt the most stringent precautions in all operations involving its use. The laboratory has been specially designed to meet the requirements of this type of work, with an elaborate ventilation system; and a rigid code of practice has been evolved for all personnel using the building, with a system of regular and detailed medical examinations. It is necessary to ensure that the average atmospheric concentration of beryllium does not exceed 2 millionths of a gram per cubic metre throughout the working day. Special care must be taken during abrading operations. Considerable assistance was provided by the United Kingdom Atomic Energy Authority during the design of the laboratory.

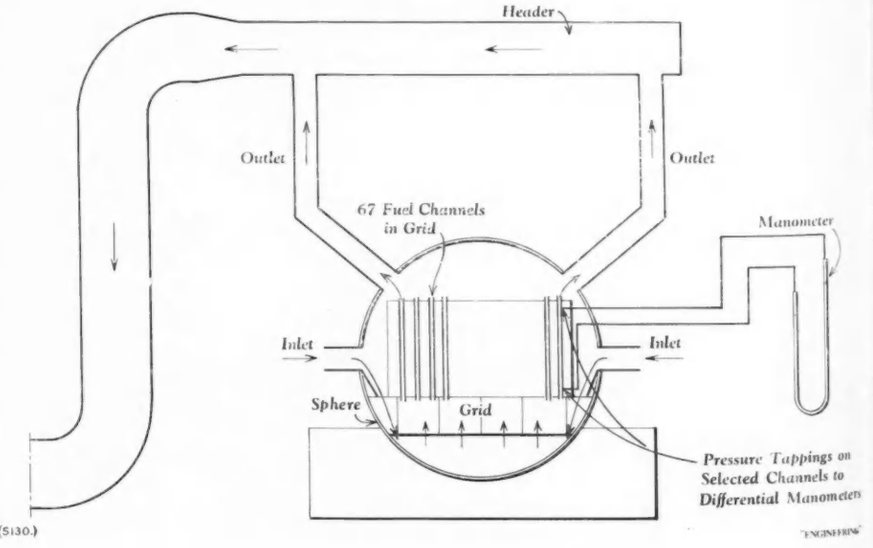
In general terms, the purpose of the laboratory can be described as the study of the chemical and physical properties of beryllium metal in fabricated form. The first stages of the programme are largely concerned with investigations on mechanical properties at elevated temperatures and with measurements of oxidation resistance in carbon dioxide. One of the major disadvantages of beryllium is its brittleness. In this connection, equipment for carrying out creep and stress-rupture investigations is at present being installed. Further subjects for future study include the welding of beryllium and the examination of the effects of aqueous corrosion.

Beryllium

Beryllium possesses a number of properties which recommend it as a possible fuel-canning material for use in gas-cooled nuclear reactors. It has a very low neutron-absorption cross-section; its melting point (1,280° C) is considerably higher than that of other metals already used for this duty; its resistance to oxidation is good, both in wet and in dry carbon dioxide; and its high-temperature strength is excellent. The ability to use this metal at very high temperatures is particularly significant. Current information suggests that a beryllium fuel-can could probably be operated at temperatures of about 600° C. This would permit the maximum gas temperatures at the outlets from the reactor to be raised by at least 100° C above the level possible in current designs. Such an increase would result in a considerably higher thermal efficiency for a nuclear power station. However, a great deal of work must be done in order to define the limiting conditions under which a beryllium-canned fuel element could be used. Thought at one time to be almost unmachineable, beryllium, which is extremely brittle, can in fact be machined with about the same difficulty as cast iron. Beryllium is obtained through the U.K.A.E.A., often from American sources, but is also produced in this country by the Imperial Smelting Corporation's plant at Avonmouth and the Murex plant at Milford



Reactor model installed at the G.E.C. Atomic Energy Division's Laboratories at Erith for studying gas flow inside reactor pressure vessels. *The model of the reactor sphere is 1/20 full size and has been devised so that a study can be made of the coolant gas flow through the reactor. It comprises a Perspex sphere, with eight inlet and eight outlet ducts. Air is drawn through the inlet ducts on the lower section, and passes through the fuel channels as shown. At certain tappings, readings of flow are taken. The model is not exactly to scale; modifications have been made for manufacturing and experimental reasons.*



(5130.)

Haven. A 6 ft by ¾ in. diameter bar may cost nearly £500 at the present stage.

Reactor Model

Another laboratory, devoted largely to mechanical engineering, contains a 1/20-scale model of a power reactor of the type being built at Hunterston. This model, which is shown on page 364, is used for investigations on the flow of coolant gas within the reactor. A sketch indicating the layout of the model is also shown. A model of the reactor core is housed in a 42 in. diameter Perspex sphere, which is a scale replica of the reactor pressure vessel complete with its supporting skirt and rings of inlet and outlet ports. This core, which is made of Duralumin, rests on a support-grid of the same egg-box pattern as is employed in the actual reactor. The vertical fuel and control-rod channels through the core are represented by tubes of a number and diameter such that the core as a whole offers proportionally the same resistance to gas flow as will the full-scale structure. There are in fact 67 channels with pressure tappings.

A motor-driven blower, coupled to the outlet ports in the Perspex sphere, draws air through the model to simulate the flow of coolant gas in the reactor. The air flow through the model is 5,250 cu. ft/min. Measurements are made of the flow of air at the inlet and outlet ports and of the pressure drop along selected channels through the core. By these means it is possible to investigate the symmetry of the gas-flow through the reactor and to study the effect of shut-down of one or more of the eight gas-circuits which connect the reactor vessel to the steam-raising units. The influence of "gags" to restrict the flow of gas through the channels can also be determined.

G.E.C. Reactor Research

In addition to the work already described, G.E.C. is engaged on a number of other research studies. Certain of these are concerned with reactors of the kind being built at Hunterston, while others are in connection with reactors of more advanced design. Reference to work on the liquid-metal-fuelled reactor system at the G.E.C. Wembley Laboratories was made in Atomic Review last week. Certain research projects are touched upon below.

Permeability of Graphite Sleeves

In the Hunterston reactors, the fuel elements are individually supported inside relatively large-bore graphite sleeves through which the carbon dioxide coolant flows. Since, in general, graphite is permeable to gas, it was necessary to find the permeability of the graphite sleeves to carbon dioxide and then to adjust it to such a value that a stable system of gas flow could be produced. Much of the work on this problem has been carried out at the G.E.C. Research Laboratories at Wembley, but experiments are at present being performed in the Heat Laboratory at Erith to measure the permeability constant for Reactor Grade A graphite sleeves.

The apparatus employed consists of a pressure vessel in which a graphite sleeve is enclosed. Carbon dioxide, at the operating pressure for the reactor, is supplied to the centre of the sleeve and allowed to pass through it and out to atmosphere through a valve. The inlet flow-rate, the pressure, and the temperature of the gas are measured, together with the pressure differential across the sleeve. These values enable the permeability constant under closely simulated operating conditions to be calculated.

Sodium and Graphite

Studies have also been carried out at G.E.C. laboratories on the penetration of liquid sodium into graphite. It was concluded that no significant proportion of the available pore volume could be entered by liquid sodium at 270° C. It has also been found that the thermal shock resistance of carbon is remarkably affected by immersion in sodium; thus ungraphitised carbons have a much lower resistance than graphitised specimens. Another study confirmed that neutron irradiation tends to destroy the crystal structure of graphite, which reverts to hard amorphous carbon. Experiments on creep of graphite gave predicted values up to 2,000° C.

Extended Surface

Research at Erith has led to the conclusion that for heat-exchanger tubes, helical extended surface will be more efficient and cheaper to produce than studded tube. The finning takes the form of a pre-formed helical strip which is placed on the tube and resistance welded in place.

Fuel Charging and Discharging from Below

As will be apparent from a drawing of the Hunterston station (Atomic Review, 15 Feb. '57), charging and discharging fuel elements is carried out from below the reactor. Studies at the G.E.C. laboratories have indicated the advantages of this system, which are as follows. Firstly, cold fuel elements inserted into the reactor undergo only a single gradual change of temperature since the lower part of the reactor is cooler than the upper zone; if inserted from the top fuel elements are subjected to a thermal cycle of cold-hot-cooler. Secondly, discharging, when the fuel element may be distorted, is carried out under gravity.

High-Temperature Gas-Cooled Reactor

As reported previously in Atomic Review (see 30 Aug. '57, and 10 Jan. and 7 March '58), the General Electric Company have been awarded the contract for a zero-energy high-temperature gas-cooled reactor (HTGC) at the Atomic Energy Authority's establishment at Winfrith Heath. The reactor should lead to the use of higher temperatures, permitting better steam conditions. There is also the possibility that a practical HTGC reactor may be designed for ship propulsion. It is thought that for larger plant, notwithstanding the higher temperatures attainable, steam plant is likely to be preferable to a closed-cycle gas-turbine connected directly with the reactor, though a mixed system has been considered in which the gas blowers would be driven by reactor-powered gas turbines.

The reactor is, for nuclear purposes, of homogeneous design since the cermet fuel elements (see Atomic Review, 10 Jan. '58) are sufficiently fine and uniformly distributed to give the effect of a dispersed fuel in the moderator. Moreover, the fuel to moderator volume ratio is such as to classify the reactor as intermediate, since a considerable proportion of the total number of reactions will be due to fast neutrons. The reactor will thus be intermediate between fast and thermal designs. The fuel elements will be contained in carbon cans and the coolant will be nitrogen, though for power reactors of this kind helium may be used.

Notes and News

Nuclear Power Stations of 800 MW

It is now possible to build a single reactor capable of more than 400 MW net electrical output so that the stations consisting of two of these reactors will have an electrical output of 800 MW. This was stated last week by Mr. A. L. G. Lindley, general manager of the G.E.C. Atomic Energy Division. The figure of 800 MW may be compared with an output of 300 MW for those stations being constructed at the present time, and 500 MW for that just begun at Hinkley Point. The advance has been made possible partly by an increase in the core size that can be contained in a given pressure vessel, partly by the development of means for removing heat from the fuel elements at a greater rate, and partly by the greater proportion of reactor output that can be economically expended in pumping the reactor coolant gas.

Atomic Power Programme

The increase in output per reactor referred to above has a far-reaching effect on the U.K. nuclear programme. Eighteen months ago it was forecast that 6,000 MW of nuclear plant would be in commission by 1965. At that time station capacities of roughly 300 MW were envisaged, so that something like 18 to 20 stations would have to be built by 1965. This programme has now been cut by 10 per cent or possibly more. Some 1,400 MW of plant is already on order, the remainder of this programme can be met by five or six stations of the new design. There will be a considerable reduction in the capital cost of plant, and, since the stations already being built will produce electrical power at costs comparable with conventional stations, future nuclear stations will produce power at even lower costs. By 1970 it is probable that there will be few conventional stations constructed.

Nuclear Power Industry Underloaded

Mr. Lindley emphasised on the basis of the conclusions outlined above that the nuclear industry is likely to be substantially underloaded. A further pointer in this direction was that electricity demand had already departed from the exponential curve that had been predicted, and though continuing to increase, it was not rising at the anticipated rate.

Exports and Home Planning

Several orders for complete atomic power stations are likely to be submitted by overseas countries during the next six months. Likely candidates are Germany, Belgium, Holland, with possible further inquiries from Italy and Japan. Germany is expected to order two stations. However, the countries with power needs most like our own, and hence most likely to need nuclear plant, are industrialised countries capable of completing the bulk of the construction and manufacturing for themselves. In many cases, therefore, the saleable commodity will be little more than know-how. For this reason, as Mr. Lindley pointed out, the result of cutting back the power programme is likely to prove serious for the atomic energy industry, which is naturally anxious to recoup its very considerable expenditure on research and development. It was stated that a single tender for a nuclear power station might cost £100,000.

Appointments at G.E.C.

The General Electric Company, Limited, announce that, as from 1 April 1958, Mr. R. N. Millar will be appointed general manager of the company's Fraser and Chalmers Engineering Works at Erith, Kent. These works form the centre of the company's mechanical engineering, and embrace the design and construction of steam turbines, turbo-blowers and compressors, mining plant and materials-handling equipment. Here, too, are the headquarters of the G.E.C. Atomic Energy Division of which Mr. Millar has been manager since its creation three years ago. Mr. Millar will still be responsible for the company's atomic energy activities, but he will be assisted in this field by Dr. K. J. Wootton who will succeed Mr. Millar as manager of the G.E.C. Atomic Energy Division.

Beryllium Cans for New Windscale Station

It is reported that a nuclear plant of gas-cooled graphite-moderated design using beryllium canning is to be built at Windscale. The electrical output may be 15 MW. The project is understood to be the responsibility of the U.K.A.E.A. Industrial Group.

Third Calder Reactor Critical

The third reactor at Calder Hall, the first of the Calder B station, became critical on 12 March. It will probably begin to feed power into the grid in about two months.

Proposed North Wales Nuclear Power Station

The Minister of Power, Lord Mills, K.B.E., has received an application from the Electricity Generating Board, under Section 2 of the Electric Lighting Act, 1909, as amended, for his consent on the building of a nuclear power station of 400 to 500 MW capacity, which it is proposed shall be linked with the pumped-storage scheme under construction at Blaenau Ffestiniog. The site is

at Trawsfynydd in the Snowdonia National Park area, and was the subject of a public inquiry on 12 February. The actual design and lay-out of the station will not be determined until after the Board has awarded the contract. Sir Ian Horobin, the Parliamentary Secretary to the Ministry of Power, told the House of Commons that there are no further proposals for pumped-storage schemes in North Wales.

EDF1 in France

On a site on the River Loire near Chinon in France there are eventually to be three nuclear power stations each with one natural-uranium gas-cooled graphite-moderated reactor. They are to be of different designs. The electrical output of the first, EDF1, will be 60 MW, and, it is reported, will require 44 per cent less uranium than the 250 to 300 MW stations being built in Britain. The EDF1, which is due to begin operating in late 1959 or early 1960, will be contained with its heat exchanger in a cylindrical pressure vessel and housed in a 165 ft diameter spherical safety shell such as that at Dounreay. EDF2 may have a spherical pressure vessel and the third reactor at Chinon a prestressed concrete vessel like those at Marcoule (see Atomic Review, 16 Aug. '57).

U.S. Homogeneous Reactor Power Station

Mr. Lewis L. Strauss, chairman of the United States Atomic Energy Commission, has announced that the proposal of the Pennsylvania Power and Light Company and the Westinghouse Electric Corporation to build a nuclear power plant under the Commission's Power Demonstration Reactor Programme has been determined by the Commission to be acceptable as a basis for negotiation of a contract. Filing of the proposal was announced by the Commission on 11 December 1957. The proposal contemplates a homogeneous reactor with a net electrical output of 70 to 150 MW, to be operated on the Pennsylvania Power and Light Company system. The reactor would operate on the thorium-uranium cycle. Under the proposal, the U.S.A.E.C. would assume the cost of research and development planned for 1958 and 1959. A decision would be made about the end of 1959, either to begin actual construction of the plant or to terminate the project, depending on the results of the research completed by that time. Cost of the project, scheduled for completion by 31 December, 1963, is estimated at 108 million dol. The proposed reactor would be the first large-scale homogeneous reactor to be undertaken by industry. It would be an outgrowth of an extensive reactor development programme at the Commission's Oak Ridge National Laboratory in Tennessee and at the Pennsylvania Power and Light Company—Westinghouse Electric Corporation laboratories in Pittsburg.

BEPO Wigner Release

Britain's first large nuclear reactor, BEPO, an air-cooled, graphite-moderated experimental pile, which has been in operation without mishap since 1949, is to have new instrumentation in the light of the Windscale findings. BEPO was shut-down in December for a periodic overhaul. Last weekend, a controlled release of Wigner energy was carried out; heat was supplied by electrically heated air and not by making the pile critical as has been the case in the past—in particular just before the Windscale accident.

O.E.E.C. Atomic Energy Projects

The extent of Britain's participation in certain atomic-energy projects of the Organisation for European Economic Co-operation was raised in Parliament recently by Sir James Hutchison. He was informed by the Prime Minister, Mr. Harold Macmillan, that both the homogeneous aqueous reactor at Winfrith Heath and the boiling-water reactor at Halden, Norway, were projects still under discussion in the O.E.E.C. and that no decisions had yet been reached. The United Kingdom was, however, taking a full part in those discussions. Asked if his reply meant that this country would have no share in the plutonium produced and no control over its use, Mr. Macmillan said the real point was that the United Kingdom had sufficient capacity for her own needs and it did not seem wise to join in these projects as a full member. We were willing to help in any way we could with advice or technical assistance.

U.K. Assistance for Eurochemic

The Prime Minister described Eurochemic as a joint O.E.E.C. project for the separation of plutonium and the recovery of depleted uranium. The United Kingdom, he declared, already possessed sufficient processing capacity and did not, therefore, participate in Eurochemic. At the same time, this country did provide advice and had indicated its willingness to give technical assistance and equipment on suitable terms.

Nuclear Energy Proceedings

The proceedings of a conference held by O.E.E.C. for industrialists in Amsterdam last June have now been published under the title *The Industrial Challenge of Nuclear Energy: Research, Uses, Social Problems*. This survey of the principal technical, economic and social questions arising from the use of nuclear energy is arranged under the following headings: progress of nuclear research on fission and fusion, collaboration of industry in this field; resources in nuclear fuel, prospecting, the manufacture of fuel elements and the processing of irradiated fuels; applications of nuclear energy to the production of electricity and propulsion; technical, economic and financial problems; and the effects of radiation, methods of protection, users' responsibility, and insurance of installation. This is the second of a series of publications on industrial aspects of nuclear questions begun by the O.E.E.C. in June, 1957.

Health and Safety

Measures for protecting the public against nuclear hazards and for co-ordinating the activities of public-health workers and organisations likely to be concerned with problems of this kind were the subject of papers presented last week at a meeting of the Royal Society of Health. Sir Ernest Rock Carling, chairman of the World Health Organisation Commit.ee on Post-Graduate Training in the Public Health Aspects of Atomic Energy, said that the hazards arising from the peaceful uses of nuclear energy could be controlled and exposures kept below a permissible level. In determining the level, account could be taken of the inescapable background arising from cosmic and other sources of radiation. In the case of military applications indeterminate exposure due to fall-out would be superimposed on the inescapable dose. So far, fall-out had added less than one per cent overall to the inescapable dose—and that inescapable dose was higher in some parts of the world by 500 per cent or more. X-rays accounted for about 30 per cent of the background in Britain. But it was essential that knowledge of the biological facts be driven home to everybody. The present view was that no dose, however small, could with certainty be said to be without adverse genetic effect. Sir Ernest drew attention to the Fleck Committee report on health and safety organisation in the U.K.A.E.A., which stated that the "Atomic Energy Authority should establish a national training centre for health physics and nuclear safety staff to cover also the health and safety aspects of the use of isotopes in medicine, agriculture and industry." He also underlined the extent to which a discipline was necessary for controlling the hazard.

An assessment of the environmental hazard was given by Mr. G. B. Courtier, Senior Principal Scientific Officer, London County Council, who revealed that on 14 October last year, three days after the Windscale accident, an unusually large amount of fission products were detected in the air about London; twice the quantity had been observed earlier in Lancashire and the West Riding. Dr. W. H. P. Minto, County Medical Officer, Cumberland County Council, who spoke on public-health considerations, discussed the local measures taken after the Windscale accident, and the conclusions to be drawn. The three papers provide an admirable introduction to health and safety aspects in the application of nuclear energy.

Isotope Course for Business Men

A course on radioisotopes designed to give senior executives in industry an appreciation of the possible applications of those materials will be held at the Harwell Isotope School from 23 to 26 September. Two similar courses have been arranged in April (15 to 18) and July (8 to 11) for members of the Institute of Directors only. The course consists of lectures on the elementary principles of work with radioactive isotopes with the emphasis strongly towards their application as tools in industry and research. The lectures will be given in as non-technical a manner as possible, by scientists experienced in the field, and will be supplemented by visits to a reactor and to the laboratories of the Isotope Division at Harwell and at the Wantage Radiation Laboratory in that area. The lectures and demonstrations will be given in the Cockcroft Hall at Harwell. Over the period of the conference delegates will stay in an Oxford college; transport from Harwell to Oxford and back each day will be arranged. The fee for the course including accommodation, meals, transport and lectures is £40 payable in advance. Applications for places will be accepted strictly in rotation; application forms are obtainable from the Registrar, Isotope School, Atomic Energy Research Establishment, Harwell.

Abstracts on Radiation Chemistry

Selected Abstracts of Atomic Energy Project Unclassified Report Literature in the Field of Radiation Chemistry and Bibliography of the Published Literature (First Annual Supplement) is published by the U.K.A.E.A. Research Group and includes papers on the subject noted up to February 1957. Compiled by Mr. R. W. Clarke and designated A.E.R.E. C/R 1575 (1 to 6) Supplement 1, it is divided into the following sections: (1) theory, interpretations, water and aqueous inorganic systems; (2) organic compounds (including polymerisation reactions); (3) gaseous systems (excluding organic compounds); (4) solid systems (excluding organic compounds); (5) biochemistry and radiobiology (excluding animal studies); and (6) miscellaneous (including colloids, corrosion, industrial applica- of radiation, irradiation equipment, general reviews, etc.). The abstract is world-wide in its coverage.

A White Paper on Atomic Wastes ?

Current programmes of research into the radioactive fall-out from the atmosphere, the Prime Minister stated recently, were outlined in the annual reports of the Medical Research Council, and statistics showing the level of strontium 90 in bone and other substances have been published from time to time. The discharge of radioactive wastes from the establishments of the United Kingdom Atomic Energy Authority was strictly controlled in accordance with the requirements of Section 5 of the Atomic Energy Authority Act, 1954. Further, these requirements were referred to in the recent report *Organisation for Control of Health and Safety in the Atomic Energy Authority* (H.M.S.O., Cmnd. 342, price 1*s.* 3*d.*).

The question of the control of waste from the nuclear power stations to be built in the future was at present being studied in connection with the proposals for the licensing and inspection of nuclear reactors, about which the Government intended to introduce legislation in due course. He would certainly consider issuing a White Paper on the monitoring system for the after-effects of waste fission products.

Nuclear Powered Ship

A nuclear power British ship may be in the water by 1964 according to Mr. W Galbraith, Civil Lord of the Admiralty, who said that a suitable system had now been selected and work on it was now proceeding.

Companies in the News

Heads Together

The Minister of Power has set up a committee of nine members of the electricity and gas industries under the chairmanship of Sir Cecil Weir to consider how the boards of the two industries can improve the " administration of the services of a like kind provided to the public." When this was announced in Parliament last week by Sir Ian Horobin, Parliamentary Secretary to Lord Mills, he was at pains to point out that the committee will not be concerned with the general policy of the electricity and gas industries, nor with competition between them. Sir Cecil Weir and his colleagues will bear in mind more particularly recent criticism in Parliament and elsewhere that the Central Electricity Authority and the Gas Council both spend money in the same area on the unnecessary duplication of services.

Examples of this abound, particularly in respect of the customer who uses both gas and electricity. There should certainly be scope to reduce man-hours spent on meter reading and cash collection, and the money paid out to the General Post Office for distributing invoices. If, however, the joint approach is extended to showrooms there is a danger that the present fiercely competitive spirit between the two industries will be affected. That would be a pity, for the consumer probably stands to gain from the fight for his custom.

The committee will do well to bear in mind that competition lies often in the hearts of the men who sell, and that the vigour and determination of their part on which it thrives can be eroded by the feeling, however slight, that it is " only for show." The elimination of wasteful duplication—what could be more so than competitive tendering, say, for power stations?—could be bought very dearly.

Power Plaint

Boiler makers are finding it increasingly difficult to be optimistic about the future, and most of them are having a testing time at the moment. The volume of work arising from the programme of the Central Electricity Generating Board is getting less, and exports are reflecting the world's tendency to build fewer orthodox thermal power stations wherever water power can be developed or nuclear power awaited. The financial results of Clarke, Chapman and Company Limited for the year ended at December 31 show a decline in trading profit for the first time in the past seven years, from £1·95 million in 1956 to £1·48 million. The fall is relatively fairly small, and could be due to having an unusually large number of contracts uncompleted by the year's end, since it is difficult to calculate the profitability of work in progress. Nonetheless, this fall in profits is in line with the general feeling in the industry, namely, that work is harder to get and not so profitable to execute.

Electrical plant manufacturers are relatively much better placed, since turbo-generators, transformers, switchgear and distribution equipment is required, irrespective of the chosen means of generation. The time when power will be generated direct from reactors is still far enough away not to affect the foreseeable future. The preliminary results of Associated Electrical Industries are encouraging about both the present and the immediate future. The group trading profits have recovered from last year's setback and it seems that they are now beginning to benefit from the heavy capital investment of recent years and the extensive changes in organisation which were still being carried out in 1956. Capital expansion has continued to involve the group in heavy expenditure and is likely to do so for some time, but 1958 may well be the first year in which it will make a substantial impact on productivity.

Heavy electrical equipment manufacturers do not appear to be short of business. World demand continues to be extremely high, and the growth potential is immense. English Electric have just reported a sharp increase in their order books, including an order from the C.E.A. for two 275,000 kW generating sets for the projected power station at Blyth and a contract for a further two water turbine generating sets for the Priests Rapids Hydroelectric Scheme in the United States. A similar increase in orders booked is likely to be announced by Lord Chandos when he addresses A.E.I.'s shareholders. The contrast between the fortunes of manufacturers of electrical machinery and of boiler plant is a reflection of the changing pattern of power production, and a good illustration of how industry, however large and powerful, can be affected by technological advance.

Great Expectation

Few chairmen of companies to-day are willing to make definite predictions concerning their companies' fortunes during the next few months. Mixed experience over the past year and the general uncertainty of trading prospects lead most of them to tell shareholders that results will depend above all on the kind of economic weather which prevails and over which their companies have no control. It is pleasantly surprising therefore to find this statement in an annual report: " I consider that the main problem during the current year will not be so much that of keeping the works busy, as that of improving the efficiency and capacity of the company's organisation so that it will be able to expand to the satisfaction of customers, company's personnel and shareholders." It was made by Mr. Harold Sinclair, chairman of Fluidrive Engineering Company.

Fluidrive Engineering ride on the expansion of demand for a relatively new product, hydraulic transmissions, for which there is a potential demand " greater than the actual business which is being secured." Mr. Sinclair told his shareholders that the value of orders booked during the year ended at September 30 was 29 per cent higher than the previous year and that this trend was continuing. Turnover rose by 9 per cent during the same period. One of the characteristics of Fluidrive's expansion is that they are spreading the applications of their Vulcan-Sinclair couplings and Fluidrive S.S.S. (synchro-self-shifting) clutches over an increasingly wide field.

No Blind Eye

Few people could expound so clearly that the future belongs to the enterprising as Sir George Nelson did in his annual statement to the shareholders of the English Electric Company, Limited. His answer to inflation is " improvements in design, improvements in production methods, and the increase in the volume of our business." Rising costs can only be answered by increased efficiency. He is by no means satisfied with his group's remarkable progress in this direction. Improved utilisation of plant and equipment is high on his list of priorities for the management's attention in the coming months. Moreover, " wherever possible, increased double shifting and a more rational deployment of manpower must be carried still further." In other words, English Electric, and British industry as a whole, must take the fullest advantage of the heavy investment of recent years.

Sir George reviewed the export position and outlook in some detail. One-third of his group's order book is for overseas customers. But, he warns, there is a trend towards long-term financing of overseas schemes, and, in his view, a wholly desirable one. " It seems to me," he said, " that we must do more than has been found possible in post-war years to spread the period over which capital equipment is financed." Long-term financing is " a competitive weapon " as well as the quality and price of the product. The plant must be sold on terms which will allow its earnings to pay for its cost. Periods of 20 years have therefore to be envisaged, and this " requires urgent study with special reference to this country's exports of capital goods."

There is much in Sir George's speech which is stimulating, not least his confidence in the future. His group's order book is " very satisfactory " at £250 million. There is as yet no evidence of a slackening in the world's determination to industrialise, despite the United States recession. English Electric have experienced " no serious diminution of incoming export orders," But should the U.S. recession last beyond 1958, with a depressing effect on commodity prices, " cause for anxiety might develop." There is nothing Britain can do about that, or little which can materially affect the situation. Nonetheless, English Electric have shown that they can do better in similar circumstances than their competitors. There is room still for aggressive promotion. The rewards in a competitive world will be for those who invest well and make full use of their investment—in plant, skills and basic research.

Bleaker House

The excellent results of Hoover and of Prestige for 1957 confirm that a tremendous recovery took place in the home demand for durable household goods. In the last quarter of the year it was the highest ever recorded both in real and money terms. Total expenditure for the year exceeded £1,000 million for the first time, £84 million greater than in 1956 and over £100 million greater than in 1955. Allowing for price increases the rise in volume over 1955 was one of 5 per cent, but there are signs that this steady expansion trend may be coming to an end, at least temporarily. There is plenty of evidence that the potential demand for refrigerators, washing machines, dish washers, vacuum cleaners, polishers, kitchen equipment, and so on, is very large and widely based over the country's income groups, but the news of unemployment and the uncertainty bet among those who keep their jobs may restrain people from entering hire purchase commitments. Mr. Arthur Keating, chairman of Prestige, notes that there are signs that the financial measures announced in September and now six months old are beginning to take effect.

The directors of Hoover are reluctant to forecast the company's prospects for 1958, mainly because of the difficult export situation which is developing. Already last year nearly all the gains came from increased sales on the home market. Turnover in the United Kingdom rose by 13 per cent, compared to a rise of only 4 per cent in overseas sales. The sharp falls in commodity prices in recent months, the board point out, may have consequences " which might jeopardise the internal position in the primary producing countries." The slowing down of industrial activity in various parts of the world and the recession in trading have " not yet assumed serious proportions," but have gone far enough to ensure that 1958 will be a difficult year, " particularly the export field where competition will be fierce."

Prestige come to very much the same conclusion, though they see the flicker of a light through the gloom. They note signs that " a slackening of general consumer demand may occur through the spring and summer." Of this there is not much doubt in the fields where both Hoover and Prestige operate, but it is comforting to read Mr. Keating's prediction that there are grounds for hoping this trend will be reserved " towards the end of the year " in both America and Britain.

In Parliament

SOUTH OF THE SAHARA

Technical assistance by European nations to countries south of the Sahara was the subject of a statement by Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, in the House of Commons last week. Mr. Harvey said that he had represented the United Kingdom Government at the conference in Accra in mid-February at which the new Foundation for Mutual Assistance in Africa south of the Sahara had been inaugurated. The meeting was very successful and the Foundation appeared to have made an excellent start.

The new organisation had been set up jointly by all the member governments of the Commission for Technical Co-operation in Africa south of the Sahara. But other countries and territories in that part of Africa would equally be eligible to receive technical assistance under the scheme. The provision of such assistance under the Foundation would start as soon as specific requests for it were put forward by governments concerned.

It was too early at present to estimate the total expenditure which member governments would eventually incur, but the House would be asked to approve for actual expenditure in the next financial year a sum of £20,000 for assistance to countries outside the British Commonwealth in this region.

PROVIDING EXPERT ADVISERS

Members of the Commission for Technical Co-operation, Mr. Harvey told Colonel Tufton Beamish (Conservative), were the Governments of Belgium, France, Portugal and the United Kingdom (whose membership covered all their respective African territories), together with the Governments of the Federation of Rhodesia and Nyasaland, Ghana, Liberia, and the Union of South Africa. Ethiopia, Somalia, the Sudan, and the Spanish territories south of the Sahara, although not members of the Commission at the present time, would be eligible for technical assistance.

Technical assistance to be given by the member governments would take the form of supplying experts, advisers and instructors to countries in the region; training personnel from such countries; and providing equipment for training purposes. The assistance would be arranged bilaterally between the donor and recipient governments concerned, in accordance with the practice followed by the Technical Co-operation Scheme under the Colombo Plan.

The new scheme was in its infancy and would take some time to develop fully. It was obviously too early to forecast what scale of operations might prove necessary and practicable at a later date. The £20,000 mentioned represented new expenditure and did not include assistance by the United Kingdom to British dependent territories in Africa or to Ghana.

GAS AND ELECTRICITY CO-OPERATE

Means of improving co-operation in the gas and electricity industries is to be investigated by a committee set up jointly by the Minister of Power and the Secretary of State for Scotland. The committee's terms of reference will be "To consider ways in which, by co-operation between the Area and Scottish Electricity and Gas Boards in the performance of their respective statutory functions, the administration of the services of a like kind provided to the public by the two industries might be improved: and to make recommendations."

Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, stated that Sir Cecil Weir, K.C.M.G., K.B.E., chairman of the British Tabulating Machine Company Limited, would be the chairman of the committee. Mr. R. R. B. Brown, Mr. G. le B. Diamond, Sir Edward Herbert, Sir John Imrie, Sir Henry Jones, Mr. C. T. Melling and Mr. Austin Morley would be members of the committee, together with another member still to be appointed. Sir Ian told Mr. G. Nabarro (Conservative) that the secretary to the committee would be Mr. W. R. G. Bell of the Ministry of Power, Thames Bank House South, Millbank, London, S.W.1. They would report to Parliament.

U.S. LIGHT ENGINEERING

An American firm engaged in light engineering is anxious to have the use of certain Admiralty buildings at Tantallon for the immediate establishment of a new industrial enterprise of considerable importance. Mr. T. G. D. Galbraith, Civil Lord of the Admiralty, said that the venture had the support of the East Lothian County Council and the North Berwick Town Council. It was appreciated, he told Sir William Anstruther-Gray, Bt. (Conservative), that it was undesirable to have buildings of that description close to the ancient monument of Tantallon Castle and a number of authorities, including the Scottish Council for Industry, had been consulted. The Secretary for Scotland felt that the site should ultimately be cleared, but there was no immediate prospect of funds being available for that purpose. It had been decided to lease the buildings to the firm concerned for a period of seven years only.

EARTH-MOVING PLANT

Mr. Aubrey Jones, the Minister of Supply, told the House that, by testing crawler tractors in the early stages of their manufacture in this country, the Military Engineering Experimental Establishment of his Ministry had done much to encourage the design and improvement of these vehicles. Similarly, and by means of development contracts, graders, scrapers, truck-mounted excavators and soil-stabilisation plant had been developed by the Ministry of Supply, primarily for use in the Services. A commercial market had been found for most of these machines and they were now being exported to the value of about £2 million annually. At the same time, he told Mr. David Price (Conservative), the Armed Forces had been able to replace many of their war-time foreign machines by modern ones of British design and manufacture.

SCOTTISH HYDRO-ELECTRIC SCHEMES

Reference was made by Sir David Robertson, the Conservative member for Caithness and Sutherland, to the position that capital expenditure on the generation of electricity by the North of Scotland Hydro-Electric Board had exceeded by millions of pounds the sums approved by Parliament. He said that twelve schemes completed were approved by Parliament at a cost of £21 million, but they had cost £44 million. The eleven schemes now in progress were originally estimated to cost £60 million, but the present estimated cost of completing them was £98 million. In the interests of the Board, as well as of the people of Scotland, was it not desirable that the Board should stop and rest awhile, consolidating?

Mr. Niall Macpherson, Joint Under-Secretary of State for Scotland, said that the reasons why the completed costs of the Board's schemes had exceeded the estimates given to Parliament when the schemes were approved, had been most carefully examined but the increased charges did not, in the opinion of the Secretary of State for Scotland, justify him in withdrawing his sanction for new schemes, and in halting the schemes in course of construction, unless they were nearing completion, as proposed by Sir David. Clearly, the Secretary of State must consider new schemes on their merits and, once a scheme had become operative, the Board had a statutory duty to proceed with it. The Select Committee on the Nationalised Industries had referred to the length of time that constructional works took to complete. Undoubtedly, in the early stages, the Board had had less experience of these matters than they had now, but the mere fact that the estimates had been exceeded in the past was not a reason for declining to go on with the schemes at present.

He agreed with Mr. A. Woodburn (Labour) that much of the trouble was due to changes in prices and to the great increase in interest charges.

ATTRACTING COMMONWEALTH TRADE

Suggestions were made by Mr. M. Clark Hutchison, the Conservative member for Edinburgh South, that the Secretary of State for Scotland, in conjunction with interested Scottish trade and commercial associations and the President of the Board of Trade, should invite selected representatives of each of the Dominions in turn to visit Scotland, with a view to increasing her trade with the Commonwealth. He said that there was immense goodwill in all the Dominions towards Scotland and that here was a chance of helping Scotland to help herself. In reply, Mr. Niall Macpherson stressed that it was the President of the Board of Trade who was primarily responsible for making official arrangements for Commonwealth trade representatives when they visited the United Kingdom under the sponsorship of their respective governments. At the same time, the Secretary for Scotland would be very glad to co-operate in making them welcome to Scotland, as also would the Scottish Council (Development and Industry).

Suffolk Nuclear Power Station

Asked by Mr. Edward Evans (Labour) about the possible construction of a nuclear power station in the Reydon district of East Suffolk, Sir Ian Horobin, Parliamentary Secretary to the Ministry of Power, said that the Central Electricity Generating Board had not yet applied for the consent of Lord Mills to the erection of a nuclear power station in East Suffolk, although he understood that the Board were investigating a number of possible sites. An application, if received, would have to be ruled upon in the light of all the circumstances, including any representations made for or against the Board's proposals to build a station on the site chosen by them.

Nickel Dermatitis

The incidence of nickel dermatitis had not been exactly assessed, Mr. Derek Walker-Smith, the Minister of Health, informed Mrs. Joyce Butler (Labour/Co-operative), but the complaint seemed to be a fairly common form of skin trouble, particularly among women. People who were sensitive to the metal might develop dermatitis after contact with a nickel-plated item of apparel. The complaint could only be prevented by avoiding contact with nickel. He would consider suggestions made by Mrs. Butler that manufacturers of zip fasteners and costume jewellery should be approached to see whether more could be done in the way of covering the metal with enamel, or by providing a substitute in the form of plastics. Mrs. Butler had pointed out that nickel dermatitis was a very widespread complaint among women and appeared to be on the increase.

British Motor Trades

Mr. Douglas Jay (Labour) desired the President of the Board of Trade to instruct the Registrar of Restrictive Practices to bring before his court immediately the distribution scheme agreement of the British Motor Trades Association. If it were legal under the Restrictive Practices Act for manufacturers collectively to compulsorily raise a levy for enforcing higher prices, surely the Act meant almost nothing at all. Mr. G. S. Lindgren (Labour) felt that garages in various parts of the country were becoming as much "tied" as licensed houses. Mr. F. J. Erroll, the Parliamentary Secretary to the Board of Trade, said he did not accept what Mr. Lindgren had said. The President of the Board of Trade would issue a third direction to the Registrar very shortly regarding the cases to be taken before the court and he would deal with the agreement of the British Motor Trades Association then.

Management

THEORY OF GAMES

A Tool for Operational Research

By S. Vajda, DR. PHIL.

Admiralty Research Laboratory, Teddington

Almost any situation can be more clearly understood and more competently tackled by using systematic methods. Increasingly this is seen to be true even in fields of activity not obviously amenable to mathematical treatment. Management, for example, has profited from scientific study; and operational research, which might be regarded as an extension of management, embraces many new and valuable techniques. One such technique is theory of games, which is not merely a device, in the words of Mr. Stephen Potter, for " winning without actually cheating," but a procedure applicable to all competitive situations, from industrial rivalry to war. In discussing theory of games, the author recognises that in a short article the subject can only be touched upon, but gives a clear indication of its scope and the kinds of procedure it employs.

A number of mathematical techniques have been developed for the use of operational research workers, and some of them have already been used extensively, while the applicability of others to practical problems remains to be explored.

The theory of games belongs to the latter category. This theory is concerned with competitive situations, be they parlour games, economic activities, or military contest. In such cases the outcome depends not only on one's own decisions, but also on those of some other person or persons, with interests of their own. A penetrating analysis of these situations provides an attractive alternative to expecting the worst while hoping for the best.

If we think of a game like Noughts and Crosses, or Draughts, then we may imagine that we have a list of all situations that might possibly arise during the play, and that we note in advance, against each situation, the move that we would make if we were faced with it. Such a list of our intended moves is called a "strategy," and in many games the number of possible strategies is finite. If both players choose their strategies in advance—rather than deciding on their moves as they go along—then the game is " normalised," that is, virtually reduced to one where either player has just one single move, and decides on it in ignorance of his opponent's decision. The essential feature of a game that interests us here is the result as it depends on the respective strategic decisions of the two players, after normalisation. (A game of chess must terminate after a finite number of moves and therefore, in principle, the two players could normalise and thereby fix the outcome of the game at the very start. Fortunately the number of strategies is so enormous that chess lovers need not worry about this happening in actual fact.)

In some games an element of chance enters in the form of dealing cards or throwing dice. Then we calculate the expected value of the possible gains and consider this to be the outcome.

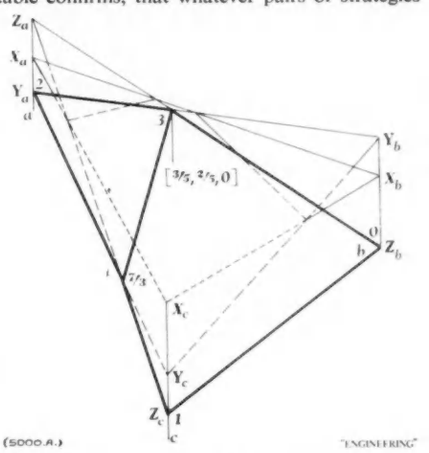
To simplify matters, think now of a game where both players can choose from just three strategies. Let the result of any pair be given in the following table, which lists the gains of A, and hence the losses of B.

		Player B's strategies		
		1st	2nd	3rd
Player A's strategies	1st	3	1	5
	2nd	4	6	0
	3rd	7	3	1

For simplicity only positive values have been taken. Each figure may, for example, represent the advantage to A that would result if the game were played using the pair of strategies indicated; clearly the advantage if A lost would be negative

Our theory suggests that each player should determine for every one of his strategies the amount which he can obtain at least with certainty, and choose that strategy which makes this guaranteed amount as high as possible. (If this amount is negative, it means that the player will not lose more than its absolute value.) Player A will thus determine the smallest value in each row and choose the largest of these minima, the " maximin." Accordingly, he chooses his first or his third strategy, and wins at least 1. Player B, on the other hand, will determine the largest value in each column, and the smallest of these, the " minimax." He then chooses his third strategy, and will not lose more than 5.

The two guaranteed amounts turn out to be unequal. It follows, and an inspection of the table confirms, that whatever pairs of strategies



are chosen, at least one of the players will regret his choice when he discovers that of his opponent. This would not be the case if the two guarantees were equal, as the reader will easily confirm. (Consider, for instance, the pay-off table $\begin{pmatrix} 3 & 6 \\ 2 & 5 \end{pmatrix}$.)

In some practical applications it is possible to compromise between strategies. This is true, for instance, if a strategy consists in investing and where one's investments can be split up among a number of shares. In other cases one can decide by chance between the strategies and may consider the expected outcome, that is the probabilistic average, as the benefit from such a procedure. This will be legitimate if one intends to play the same game a great number of times.

Consider (Fig. 1) three points *a*, *b*, and *c*, in a horizontal plane (the points are shown but not joined by lines).

Let them indicate, respectively, the three strategies of player A. Any mixture of strategies in the above sense is then indicated by a point (e.g. $[\frac{2}{3}, \frac{1}{3}, 0]$) on the same plane the barycentric co-ordinates of which are the relative shares of the three strategies. (By the barycentric co-ordinates of a point we mean the amounts of those weights, adding up to unity, which would when attached to *a*, *b* and *c*, give that point as their centre of gravity.)

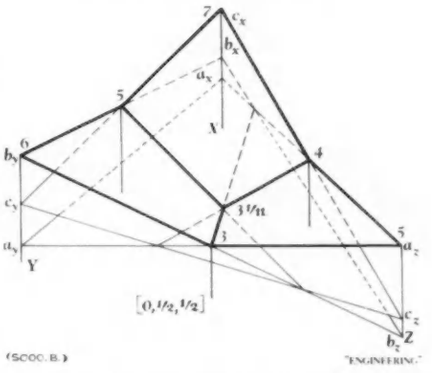
Taking any point (not shown) within the triangle *a b c*, and vertically above it the point (not shown) with a height equal to the resulting pay-off to A when B chooses his first strategy, then all such points lie on a plane $X_aX_bX_c$. The figure shows three planes (as seen from below), corresponding to the three strategies of B, namely $X_aX_bX_c$, $Y_aY_bY_c$, and $Z_aZ_bZ_c$.

Whatever point A chooses, his guarantee equals the elevation of the point on the lowest plane above it. He will therefore choose that point in his triangle which makes this elevation largest. In our case it is the point with barycentric co-ordinates 3/5, 2/5, 0. The lowest point above it on one of the three planes has a height of 3. (The thick lines represent the envelope of lowest points defined by the intersecting planes. Long and short dotted lines have points on one or two planes in front of them respectively.)

Fig. 2 gives an analogous picture of B (seen from above). The three planes of A's strategies are now $a_xa_ya_z$, $b_xb_yb_z$, and $c_xc_yc_z$. B will choose that point of his triangle which makes the point on the highest plane above it as low as possible. It lies here half-way between his second and his third strategies. The bary-

Fig. 1 (left) A competitive situation may often be tackled using a combination of several strategies. Such a combination of three strategies may be represented by a point within a plane triangle, each vertex of which corresponds to one of the strategies. A three-dimensional construction gives the most desirable proportions in which the strategies should be combined.

Fig. 2 (below) If Fig. 1 corresponds to a mixed-strategy situation from the point of view of a player A; the same situation can also be represented as it appears to his opponent B by a second three-dimensional construction.



centric co-ordinates are 0, 1/2, 1/2 and the height is again 3. Thus, if we are allowed to consider mixed strategies, the minimax equals the maximin.

The Main (Minimax) Theorem of the theory of games asserts that it is always possible to find a pair of mixed strategies such that the two resulting guaranteed amounts are equal, provided that both players have a finite number of strategies to choose from. The common value is called the " value of the game."

Other branches of the theory deal with cases of more than two players, of infinite numbers of strategies, and with situations where the interests of the players are not necessarily diametrically opposed, so that a compromise between competition and co-operation is indicated.

Automobile Engineering

TEN-PLUS EXAMINATION FOR ROAD VEHICLES

Compulsory annual inspection of road vehicles 10 years old or more, and of less than 30 cwt. unladen weight, is expected to start this autumn. A great deal of preparatory work has already been done by the Road Research Laboratory of D.S.I.R. in investigating the efficiency of a wide range of equipment which is now available for measurement of braking and lighting performance, and examining ways by which the state of the steering and other items affecting safety could be checked. The results were summarised in a paper read before the Automobile Division of the Institution of Mechanical Engineers by Mr. G. Grime, O.B.E., M.Sc., and Mr. R. D. Lister, B.Sc., on 11 March, in which the authors discussed the grounds for believing inspection to be a good thing, considered what it may be expected to accomplish and examined the apparatus and methods at present available.

On the need for inspection the authors say "There is direct evidence from accident statistics that in a certain number of accidents every year some vehicle defect, generally a major one, is present. The Ministry of Transport and Civil Aviation records of personal-injury accidents in 1955 show vehicle defects in 3·3 per cent of all accidents (about 7,200) and dazzle in 1 per cent of all accidents (about 2,000)." They go on to argue that the number of defective vehicles is much higher than these figures would suggest.

Large numbers of defective vehicles were revealed by the vehicle testing station at Hendon, but an analysis shows that the greatest single fault was defective aiming of headlights, which was found on 61 per cent of private cars under 10 years old and 83 per cent of older vehicles. On the other hand, defective foot-brakes, which in this context means those producing a braking force less than 40 per cent of vehicle weight, were found in less than 1 per cent of the vehicles up to 10 years old and in 11 per cent of the older vehicles. One vehicle in five required attention to the steering mechanism, one in seven had a side or rear light out of action and one in six a missing stop light. No comprehensive surveys of this kind have been described for commercial vehicles.

Turning to the improvements resulting from vehicle inspection, the authors are cautious. For example: "Observations of the prevalence of glare from headlamps in the United States have shown that glare was significantly less in certain States where vehicle inspection was carried out than in others where no inspection took place.

"It is much more difficult, however, to find reliable evidence of the effect of vehicle inspection on accidents. It is certainly true that the average death rate per vehicle-mile for all American States enforcing vehicle inspection is lower than for all those without it, but this is not conclusive proof of the effect of inspection, since those States which have vehicle inspection are probably those which are most interested in traffic safety and which make use of all kinds of other safety measures. The magnitude of the effect of inspection on accidents has not been therefore accurately assessed."

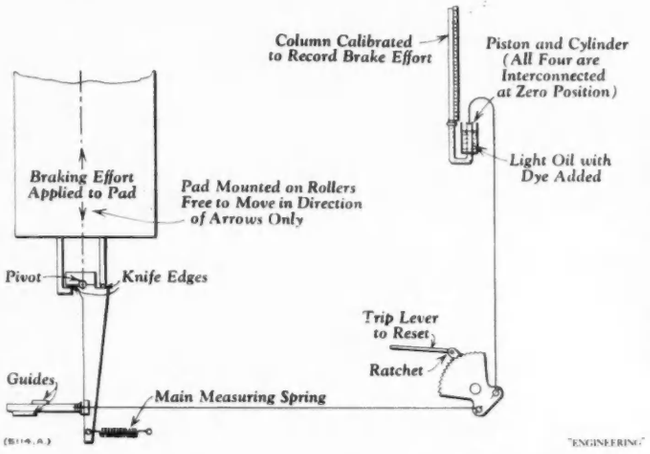
Figures quoted from British accident statistics for 1955 show that 60,200 pedal cycles were involved in accidents and 3·2 per cent of them were defective. Of 3,850 motor-assisted bicycles in accidents 4·3 per cent were defective; of 116,300 cars and taxis only 1·8 per cent were reported defective but of 58,300 goods vehicles, 2·9 per cent were defective. The percentage for public service vehicles was 1·2. As the authors say, "The inference is that on the grounds of safety, if cars are to be inspected, no other class should be omitted from the inspection procedure. Pedal cycles have a particularly high percentage of defects but this may perhaps be because it is easier to detect defects in bicycles than in other vehicles."

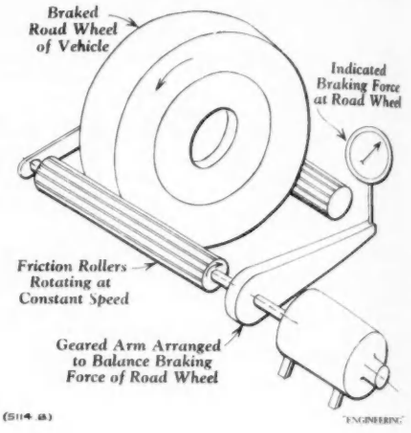
It is generally agreed that tests of brakes, headlights and steering should be included in any scheme of inspection, but it is difficult to determine the overall effect of vehicle testing, and the relative importance of separate items is even more difficult to assess. On the results of the Hendon tests the authors suggest that tyres, rear and stop lights, direction indicators, windscreen wipers, suspension systems, exhaust systems and a general under-vehicle inspection should be included, although police reports give accident evidence for only tyres and rear lights in proportions comparable with brakes, steering and headlights.

The effectiveness of inspection in securing improved vehicle condition on the road will vary from one item to another. "Inspection is most effective for items which deteriorate progressively, especially if they also have a long life, so that a fault is rectified only after long delays. Amongst those for which it is least effective are items which fail suddenly such as rear, side and stop lights. For these items it is particularly important to improve the average life, and to encourage more careful maintenance by drivers. This better maintenance may perhaps result indirectly from vehicle inspection.

"Items which deteriorate appreciably during the interval between inspections, such as play in steering and the condition of tyres, can be maintained in a satisfactory state by adopting higher standards appropriate to the inspection interval." The authors therefore suggest that the standard required at inspection should be so high that the probable deterioration by the next inspection will not bring the condition below acceptable limits. They concede however that if applied to tyres this would probably create strong objections through compulsory scrapping of covers which still had 6 to 12 months' wear left in them. They appear to ignore the fact that the police are already fully armed with powers to take action against all the defects covered by inspection, and many others, at any time.

A variety of equipment is available for measuring braking and lighting performance of four-wheeled vehicles and motor cycles, but for steering, although equipment is manufactured and used in garages for measuring the various wheel angles and alignment, there is no commercial equipment with which a rapid assessment of the effects of wear and deterioration can be made.


Column Calibrated to Record Brake Effort
Piston and Cylinder (All Four are Interconnected at Zero Position)
Light Oil with Dye Added
Braking Effort Applied to Pad
Pad Mounted on Rollers Free to Move in Direction of Arrows Only
Pivot
Knife Edges
Trip Lever to Reset
Ratchet
Guides
Main Measuring Spring
"ENGINEERING"


Braked Road Wheel of Vehicle
Indicated Braking Force at Road Wheel
Friction Rollers Rotating at Constant Speed
Geared Arm Arranged to Balance Braking Force of Road Wheel
"ENGINEERING"

Vehicle brakes can be tested in the laboratory in different ways. Fig. 1 (left) shows the arrangement used when the vehicle is driven on to floating platforms (one for each wheel), and Fig. 2 (right) the principle of the roller tester.

Brake-testing methods fall into three groups depending whether they rely on measurement of the braking force at the wheels, deceleration, or the distance required to stop from a known speed. There are two main types measuring braking force at the wheel, the platform type and the roller type. The former has four spring-loaded platforms on to which the vehicle is driven at low speed, and the brakes applied. Movement of each platform is transmitted to a piston which displaces liquid in a column, showing the braking force at each wheel. This type is widely used in the United States for compulsory inspections. The roller machine may have four or two pairs of electrically-driven rollers on which the wheels of the vehicle rest. The braking force at each wheel is registered by a direct-reading dynamometer.

Decelerometers exist in considerable variety, usually consisting of a pendulum with viscous or magnetic damping, a U-tube containing liquid, a series of tilting tubes or simply a box made to certain proportions which topples over when the required minimum deceleration is exceeded.

Apparatus which measures braking distance requires accurate determinations of vehicle speed at the instant when the brakes are applied. The only practicable method at present involves fitting a switch to the brake pedal which either fires a small detonator or pellet to mark the road surface when the pedal is depressed, or triggers a counter which records the number of revolutions of a fifth wheel towed behind the vehicle. Speed may also be measured with a fifth wheel or by contact strips placed on the road surface to time the passage of the vehicle over a short measured distance near the braking point, or

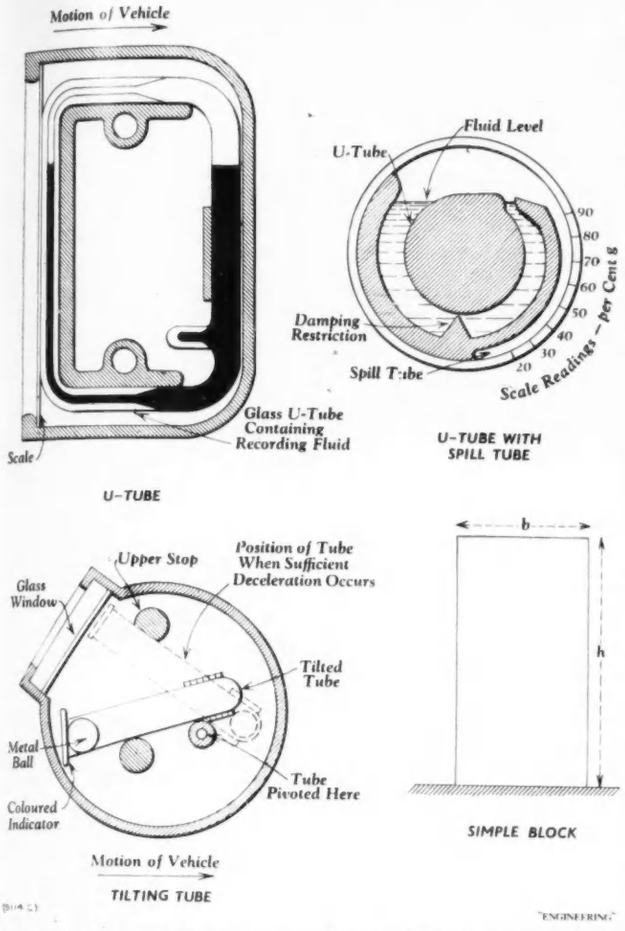


Fig. 3 Braking can also be measured by decelerometers. The simple block will tip when the percentage deceleration exceeds $\frac{b}{h} \times 100$.

by previously calibrating the vehicle's own speedometer. All this obstructs the free flow of vehicles necessary in a busy testing station.

For a rapid check to determine deterioration of steering and excessive play due to wear, a visual check is usually adopted but during the Slough road safety experiment an apparatus was developed which measured the amount of play at the steering wheel rim when a torque of 30 lb-in was applied, with the nearside front road wheel clamped in the straight ahead position.

Auxiliary lamps are checked visually and a photocell instrument has been developed in the laboratory for checking the intensity of rear lights.

The laboratory has examined a number of commercial headlamp testers for accuracy and convenience in use. The Newnham checks aim and focus against a calibrated screen and uses a separate light meter to measure intensity. Lucas, Cibié and Kent-Moore use an optical system consisting of a condenser lens and screen on which the beam pattern is reduced on a small scale and the aiming error read off by estimation from the calibrations. A photocell measures beam intensity. Various methods are used for aligning the apparatus accurately in relation to the vehicle.

The Weaver consists of an adjustable screen, a device for orientating it correctly in relation to the vehicle and a photoelectric cell. A gun-sight is used to align the tester with the centre of the vehicle and set the screen perpendicular to the axis of the vehicle. A more recent model projects the image of the headlight pattern on to an assembly of four photoelectric cells in which currents from one pair are balanced against each other to give a dial reading for vertical aim and those from another pair similarly for horizontal aim, while the total output of the assembly gives a measurement of intensity. Misaim is measured by the amount it is necessary to deflect the beam pattern to achieve balance of the photocell assembly.

The Crypton tester, based on a Road Research Laboratory design, is a simple device using a straight edge placed in the beam in such a way that the direction of the shadow projected on to a vertical screen placed almost parallel to the beam can be compared with calibration marks on the screen. A separate one is used for each lamp and both vertical and horizontal aim can be checked.

Turning now to the relative accuracy of the various equipment under practical conditions of use, the report shows that there are considerable variations. Readings with the platform type brake tester seem to depend on whether the driver was familiar with the machine. Variations between different drivers were 20 to 40 per cent. Variations of the speed at which the vehicle arrives on the platform, even in the recommended range of 4-8 mile/h, can affect the readings by some 30 per cent independently of the differences between different drivers. Thirty tests with one driver on a vehicle known to have good brakes with drums free from eccentricity and, judging by road braking results, no serious brake unbalance resulted in ratios of left/right wheel braking forces varying between 0·91 and 1·30. During a stop on the machine the wheels do not complete one revolution and the readings may therefore be affected by drum eccentricity or by distortion which arises during braking. A possible weakness of the roller machine is slip between tyre and rollers, especially in wet weather, but in either state, readings of brake efficiency up to about 70 per cent were not affected by tyre slip. Lower limits were, however, imposed by smooth or muddy tyres. However, owing to load transfer on braking at high decelerations there is no exact correlation between roller and road results. If the front wheels lock at a certain pressure when tested on the rollers they may not do so during braking on the road, because of weight transfer, but rear wheels may lock earlier than the static tests suggest.

Decelerometers are of course affected by vehicle tilt and the results are therefore affected by the degree of nose dive experienced during braking. Vibration may give rise to errors and it was found impossible to record motor cycle braking performance with a pendulum meter because the meter usually crept up to the maximum on the scale, presumably owing to vibration.

In general, there were variations between readings for a given driver of 12 to 24 per cent with a pendulum meter and variations between drivers of as much as 17 per cent. Use of a pressure gauge on the pedal gave more consistent results, but this increases the test time. Recording decelerometers were found capable of giving a complete record of braking behaviour but evaluation and interpretation takes time, which discourages their use for compulsory vehicle tests.

Variations between different drivers and in readings obtained by one driver were proportionately greatest on the platform machine. Detailed statistics are also given for the performances of the various types of headlamp tester.

The authors point out that the standards to be used when testing is first introduced may have to be determined by the capacity of garages to deal with the volume of adjustment and repair work generated. Since vehicles over 10 years old number about 2·5 million, there may be difficulty in carrying out the work quickly if high standards are imposed immediately. They concede further that it is difficult to determine limits on agreed grounds of safety for play in steering, stopping power and balance of brakes, aim and intensity of headlamps and intensity of rear lights. What they do not mention is that some rear and stop lights have already reached an intensity where they are creating a new dazzle problem.

Perhaps significantly, no mention is made in the paper of any apparatus for testing bicycles and as the Government statistics for 1956 show defects on bicycles as contributing to 27 per cent of all accidents involving vehicle defects, their action in this respect may well indicate how they propose to hold the balance between the saving of life and political expediency.

Fig. 4 Cibié headlamp testing equipment.

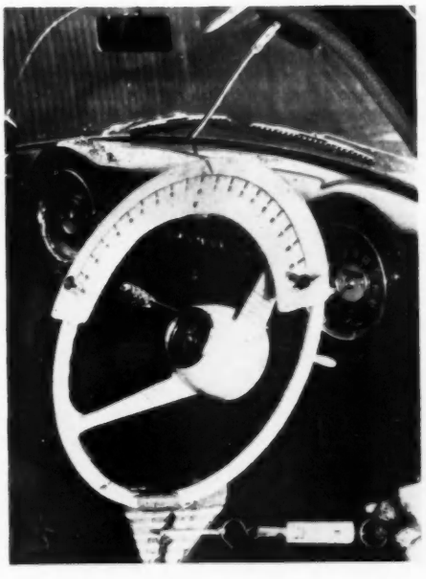


Fig. 5 Equipment for measuring steering play.

Continuing **Automobile Engineering**

MOTORING TO THE SOUTH POLE

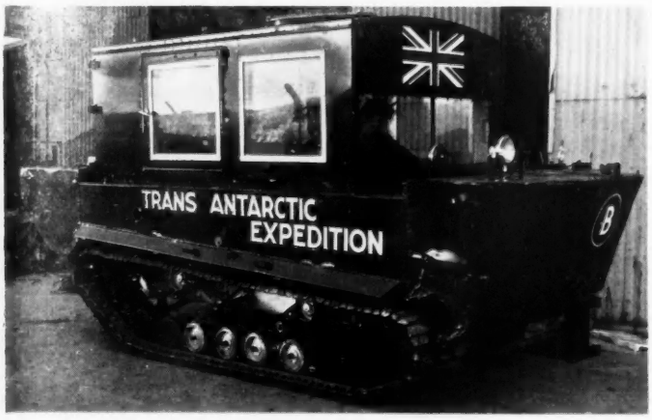
By Gordon Wilkins

Equipment of the British Commonwealth Trans-Antarctic Expedition

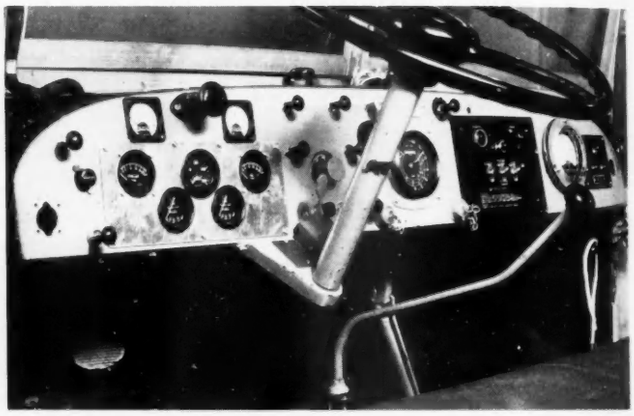
Three types of mechanical vehicle were used by Sir Vivian Fuchs and Sir Edmund Hilary in their Trans-Antarctic expedition: Ferguson tractors, Tucker Sno-Cats and Studebaker Weasel amphibians. Hilary's party starting from Scott Base was the lightly equipped support party which went on to the Pole after laying stores depots and it used three light Ferguson farm tractors which were the first land vehicles ever to reach the South Pole. Fuchs, with the slow moving scientific expedition pausing frequently to make soundings and other observations, drove right across the Antarctic Continent with his heavily laden Sno-Cats, supported initially by the Weasels.

The Ferguson tractors made by the Standard Motor Company in England were fitted with Norwegian-made crawler tracks over the front and rear wheels with extra pneumatic-tyred idler wheels in the centre. They had petrol engines giving 30 b.h.p. at 2,200 rev/min on a compression of 6 to 1. These were low-rated versions of the power unit used in the Standard Vanguard car. Electrical systems were insulated

Modified Sno-Cats had double walls and 260 b.h.p. engines.



The Weasels were fitted with crawler tracks.



Instruments and controls on the Sno-Cat dashboard.

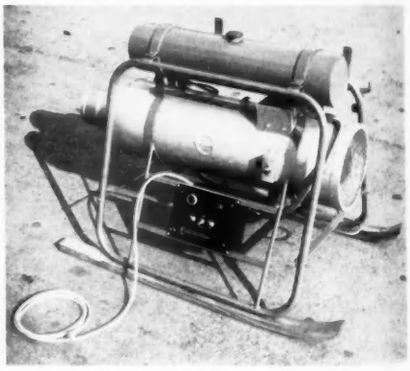
with silicone rubber which remains flexible at very low temperatures; oversize batteries and starters were employed and Ki-gass petrol injector pumps were used for cold starting. Special sealing was employed on ignition and other components to keep out the fine wind-driven snow.

The Tucker Sno-Cats and Studebaker Weasels were extensively modified by the British Fighting Vehicle Research and Development Establishment and fitted with extra equipment by Smiths. The Weasel Amphibian is powered by a 2·8 litre Studebaker six in-line engine giving 75 b.h.p. at 3,800 rev/min. It was fitted with a special heavy-duty gearbox giving three speeds and reverse and driving through a two-speed rear axle providing six forward speeds in all. Maximum speed was about 30 mile/h but when hauling a two-ton payload on sledges, average speed was 10 to 20 mile/h. Sealing against snow was a serious problem. This is illustrated by the fate of a wooden packing case which had been emptied and discarded with its top section nailed back in place to keep the inside dry in case it was needed later. When it was eventually opened it was found that snow had seeped in through a nail hole and the whole inside of the box was packed solid with snow.

For the Weasels a double wall cabin was made in aluminium with double glass windows. All joints were sealed with a special rubber compound, and silica gel was placed between the glasses to combat misting. Each vehicle carried a Smiths combustion heater modified to run on a 50-50 mixture of high-volatility high-octane petrol and paraffin. This provided an output of 50,000 B.t.u. per hour and at air temperatures of minus 55°F it was possible to raise engine and battery box temperatures by 100°F in 4 minutes. Normal Smiths fresh air car-type heaters were also used for driver and passengers giving about 9,375 B.t.u. per hour. The average Weasel weighed nearly 3,200 lb, which with tracks 20 in. wide gave a ground pressure of 2·1 lb/sq. in. on hard surfaces and 1·7 lb/sq. in. on soft snow. The vehicle would easily climb a gradient of 1 in 5 even on ice, hauling a two-ton payload on sledges. Fuel consumption varied between 0·7 mile/gal and 7 mile/gal.

For some of the time the Weasels led the way and when they fell into crevasses were hauled out by the Sno-Cats which were following.

The four-track Sno-Cats manufactured by the Tucker Corporation in America were initially considered rather frail for this job and were modified. Bodies were given double walls and there was double glass in the windows. The Chrysler V-8 M56 industrial engines were given Stromberg aero carburettors with twin float chambers; mechanical tappets were used instead of hydraulic and as modified the engine gave 260 b.h.p. Both mechanical and electric fuel pumps were provided. Transmission is through Chrysler 3-speed gearbox, and although a clutch is provided gears are not normally shifted on the move. A hand throttle is fitted in addition to the accelerator, so driving is quite simple. Combustion heaters were fitted and cold chamber tests showed that the engines would start at minus 40°F or at temperatures down to minus 55°F with some pre-heating. In addition to the combustion heater a Smiths fresh air heater with an output of 11,900 B.t.u. per hour was installed in the cabin. One vehicle arrived at Scott Base with a cracked chassis lashed together with wood as a result of a fall into a crevasse.



Heaters were fitted to both vehicles.

Research and Development

INSTRUMENTS FOR FLIGHT DATA

42nd Physical Society Exhibition

Whatever may be the lag between research and production, there is often a greater lag between production and de-classification. It is the second lag that makes the 42nd Physical Society Exhibition present certain aspects of the industry with less emphasis than they deserve. Missile guidance equipment, for example, is at the forefront of instrument development, yet most of it cannot be exhibited. The result is that the Exhibition tends to emphasise the most recent improvements in a large number of standard items such as amplifiers, microscopes, oscilloscopes and radiation counters. However, it is noticeable this year that there is an increased amount of servo, computer, and flight-data equipment on show. The exhibition will be held in the Old and New Halls of the Royal Horticultural Society, Westminster, London, from March 24 to 27.

The basis of a complete system for the simultaneous recording of the outputs of seven transducers under flight or trials conditions will be exhibited by Mervyn Instruments, Woking, Surrey. Magnetic-tape forms the recording medium and it is played back in an analysis office. The complete system is known as Midas (Mervyn Instruments Data Analysis System). It consists of three main units: recorder and power supplies; calibrator; play-back unit and analyser. Recorders are available in two forms. One is intended for use in mobile applications and is small and light enough to be used for fighter aircraft. It has a tape capacity of 900 ft. The other form is intended for operation from a.c. mains, and is transportable; it has a capacity of 1,800 to 2,700 ft. Both units can be supplied with a tape speed anywhere between 0·1 and 100 in./s, and incorporate eight interchangeable plug-in brick units—each containing electronics for one channel. The eighth channel is reserved for a reference signal for error cancellation.

MEMORY CIRCUITS

A frequency-modulated carrier system is normally used, the carrier frequency being adjusted to suit the tape speed. The calibrator unit is used to calibrate the frequency-modulation channels on the recorder, reproducing on a peak-reading voltmeter the deflection that would be obtained on the recording pen of the play-back unit. Both calibrator and the play-back unit are standardised against built-in crystal oscillators and, therefore, any number of recorders may be set up quite independently, and without running any tape. The play-back unit consists of a tape deck with a tape speed of 1 in./s. A higher speed is also provided for speech editing in conjunction with a footage indicator. For all other purposes a speed change is employed, which allows the upper frequency limit of the recorder frequency-modulation channels to be presented on recording pens that have a limit of 100 c/s. There are eight amplifier channels which can also be switched independently to operate as frequency-modulation demodulators. In the latter function they include a gate and memory circuit so that if "drop-outs" occur, no spurious signals are produced.

The analyser consists of a further tape deck with two alternative closed loops 20 ft and 160 ft in length. It serves to re-record the waveform from any one of the information channels plus the reference channel at 1·5 in./s and then to play it back at 45 in./s. The output from the frequency-modulation demodulator, after error cancellation by the reference channel, is then scanned by a wave analyser of the superheterodyne type. This draws a frequency versus amplitude spectrum on a potentiometer recorder. Amplitude errors are about 1 per cent and mean frequency errors 0·1 per cent.

An air data computer will be shown by Elliott Brothers (London) Limited, Lewisham, London, S.E.13. The miniature system, installed in aircraft, supplies continuous flight information to the pilot, auto-pilot and other services. Basic data are obtained from pitot, static and temperature transducers. These supply signals to the transistor and magnetic amplifiers of the computer where, by the use of differentials, cams and servo-operated gearboxes, the desired outputs are achieved. The same firm will also show a small rate gyro, developed for weapon use. It is 3 in. high, 1½ in. in diameter and weighs about 14 ozs.

A range of transducers will be shown by J. Langham Thompson Limited, Bushey Heath, Herts, including their linear accelerometer type LA2. In it, the sliders of twin potentiometer elements are coupled to a seismic mass by means of two compensating springs. Parallel slider motion and uniform contact pressure are achieved independent of the mass displacement. The system is damped in silicone fluid, with expansion chambers to compensate for changes of oil volume with temperature. The potentiometers are available in resistances ranging from 2,000 ohms to 20,000 ohms. The resolution is generally better than 0·7 per cent and a working temperature range from − 40 to 100° C is envisaged. Life testing over 12 million operations has shown the calibration to be unaffected. Instruments now cover ranges $\pm 1g$ to $\pm 100\ g$.

Apparatus that can be used to study the behaviour of materials exposed to high temperature conditions such as exist, for example, behind intense shock waves, will be shown by the Royal Aircraft Establishment, Farnborough, Hants. The apparatus is intended to provide a high-speed jet of high temperature gas. It is based on the apparatus developed by R. Weiss; the jet is derived from a carbon arc.

By means of tangential jets, water is made to whirl in a cylindrical insulating box. The water is vented through a central aperture in one end, and so a cylindrical air channel is maintained through the water along the axis of the box. The arc cathode is a carbon disc fitted to the end of the box opposite the water vent. The disc has an aperture at its centre, of a size that provides for the free passage of gas between the air channel and the exterior of the box, but prevents the egress of water. A carbon rod a little smaller in diameter than the air channel is inserted through the vent aperture to act as an anode. The diameter of the arc struck between the electrodes is restricted by the water surface of the air channel; this gives a higher current density and temperature than would be possible with a "free air" arc. When the arc is running, water is evaporated and issues as a jet of hot steam through the aperture in the cathode. Temperatures of 12,000 °K and speeds of several thousand feet per second have been reported. Evidence of the high temperature is provided by the broadening of the Hβ line, which will be seen with spectroscopes attached to the exhibit. The nozzle of the present apparatus is about 0·25 in. in diameter and the power input is about 25 kW.

Another exhibit on the same stand is a rocket-borne saturable-inductor magnetometer. It has been used in rockets to aid in the measurement of attitude. An oscillator provides an energising current for the primary coils of the magnetometer. The output from the secondary coil is amplified and rectified to give a direct voltage proportional to the magnetomotive force across the ends of the magnetic core. Thus, the magnetometer will give a voltage proportional to the cosine of the angle between the axis of the core and the direction of the earth's magnetic field.

A gyro response test console will be shown by the Solartron Electronic Group Limited, Thames Ditton, Surrey. The equipment consists of a number of Solartron standard instruments, together with other special units. The JY 747 console has been designed specifically for the examination of rate gyroscopes under dynamic conditions. The gyro under test is mounted on a frame in which it receives an oscillatory vibration of controlled frequency and rate. The pick-off output is demodulated and the resultant signal examined on a resolved-components indicator, a number of readings at constant rate and varying frequency giving the information necessary for the preparation of a Nyquist diagram of the gyroscope. It is also possible to determine the gyro damping factor.

COMPUTING AND SIMULATING

The Armament Research and Development Establishment, Fort Halstead, Kent, will be displaying computing and data handling equipment to show the advantages of semiconductor devices. Plug-in printed circuits are used throughout. Four basic units of a fast parallel multiplier are shown arranged to multiply two numbers, each of nine binary digits. The operations of successive additions and shifting are carried out simultaneously. In the final equipment 80 such units will be used to multiply two numbers, each of 40 binary digits, in a time of 25 μs. Location of a fault within this multiplier is facilitated by the simple logical form of its structure, and may be carried out extremely quickly by the digital computer itself.

On the stand of E.M.I. Electronics Limited, Hayes, Middlesex, an analogue computer will be used to simulate a typical complicated chemical engineering process to provide a solution to the problems associated with a new plant design. Generally, the plant which is being simulated forms a closed loop and consists of an assemblage of three kinds of units: storage tanks, operating columns, and the connecting pipes with their associated pumps. The individual characteristics of each of these can be simulated with a computer. Typical aims of such an analogue study are: to assess sensitivity of control and stability margin and to determine whether, for example, simple proportional control is sufficient; to assess the rate of propagation of disturbances—for example, to find how soon the failure of any pump will cause trouble in the rest of the plant.

Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, will be showing a basic unit for the construction of digital computing systems. A single basic transistor circuit has been designed from which a complete digital computing system may be constructed. Although the circuit is slower than some of the more complicated existing circuits, the company expect it to find applications in fields of process control and data processing where speed is often less important than reliability and ease of maintenance. The basic frequency of the system is 10 kc/s per second. A binary-decimal converter constructed entirely from these basic units will be shown.

Various exhibitors will be showing materials for computers. Mullard Limited will be showing small cores in several grades of Ferroxcube, having rectangular hysteresis loops, widely used in computers as storage and switching elements. Examples of wire matrices and matrix stacks, together with individual cores, will be shown. The Plessey Company, Limited, will be showing compact information stores than can be obtained by evaporating or printing electrode systems on to a single crystal of barium titanate. Such stores, with access times of 10 microseconds, are slightly slower than analogous magnetic devices but can operate at the low powers and voltages

Continuing
Research and Development

that can be obtained from transistor circuits.

Single-crystal barium titanate suffers from some disadvantages in memory circuit applications; for example, poor fatigue characteristics. Other ferro-electric crystals including guanidine vanadium sulphate hexahydrate, guanidine aluminium sulphate hexahydrate, glycine sulphate, and triglycine sulphate will be shown by the National Research Development Corporation. Preliminary tests show these crystals to have memory properties superior to pure barium titanate.

A small lightweight scaling unit of low power consumption will be shown by Avo Limited. The unit employs small ferrite magnetic cores as bi-stable elements in a scale-of-ten circuit, together with a magnetic count indicator in which the currents flowing in the scaling circuit magnetise thin strips of nickel iron mounted around a balanced pair of compass needles. The current pulses to operate the indicator are obtained from a circuit employing transistors. The power required to operate a complete scaling unit is little more than the power required for the first scale of ten. This is of the order of 3 mW for a count rate of 1,000 per second. The resolving time of the circuit is approximately three microseconds and the maximum mean count rate, fixed by the collector current rating of the transistor, is 250 kc/s.

An increasing number of simulators are on show this year. A machine that produces voltages between segments of a commutator similar to the voltages developed in a full scale motor or generator will be displayed by the Morgan Crucible Company Limited. Brushes can be tested under full load conditions in order to estimate wear rate and commutating ability. Every segment on the commutator is connected to one of four slip rings, the connections being cyclic: out of 48 segments every fourth one is connected to the same ring. The rings feed, via copper graphite brushes, a lattice of 0–50μH tapped inductors, which inject the required voltage between segments when their currents reverse. Direct current (10A) is fed to the brushes on test on the commutator from a battery on float charge. This current is shared between the four coils in such a way that two reverse as each segment passes. Maximum inductance is sufficient to produce heavy sparking at the trailing edge of the brushes. Brush contact potential may be measured by a small probe brush traversing the commutator at some multiple of four segments away from one of the main brushes.

A colour print simulator will be demonstrated by Hatfield Instruments Limited, Horsham, Sussex. The main drawback of speedy production of colour prints is the difficulty of assessing the correct exposure. At present there are two major methods in use: one is by integration of the colour of the whole negative and assuming that most subjects will give a neutral grey; the other is by repeated trials and visual judgment. The first method can lead to gross errors and the second is laborious. The basis of the new equipment is a closed-circuit colour-television system, whose characteristics can be adjusted to match those of a desired printing system. Controls are provided which correspond to the variables in the printing process. By operating these controls to obtain the desired result on a visual display the correct printing conditions may be found directly without the need for making trial prints.

A generator that produces a train of electrical pulses similar to those coming from a telephone dial will be shown by Siemens Edison Swan Limited. If telephone exchange selection circuits are to respond accurately, the train of impulses generated by dialling cannot depart by more than a certain amount from the design standard. The generator shown is an electronic device that can introduce known amounts of different types of distortion. The effect of this signal on a standard selector will be demonstrated.

Book Reviews

MORE NEEDFUL THAN GOLD

History of the British Iron and Steel Industry. By H. R. SCHUBERT. *Routledge and Kegan Paul Limited, 68/74 Carter Lane, London, E.C.4.* (60*s.*)

Of all the metals of commerce iron (using the word in its widest sense, to embrace all the products of ferrous metallurgy) is the most important. It has held this position for a very long time. An Englishman writing *c.* 1240 referred to the use of iron as " more needful to men than the use of gold," and added that " well-nigh no handiwork is wrought without iron." This, as Dr. Schubert points out, was no mere eulogy. It stated truly the importance even then of the iron trade of the British Isles.

The history of ironmaking is divisible into two major periods. In the first, which commenced in the British Isles about 450 B.C., and lasted until about 1775, charcoal fuel was the distinguishing feature. By the latter date a series of technical developments had made possible the substitution of mineral fuel for charcoal, and at the same time the transition from water power to steam power began. The first, or " charcoal " period can itself be divided into two parts. From the earliest records until *c.* 1490 the only process used for iron production in this country was the direct process, in which iron was extracted directly from the ore in a malleable state. At the turn of the Fifteenth Century the indirect process began to be used, and by about 1540 it had become the principal method of production. Iron was now smelted in a blast furnace, and the resulting cast iron, which contained a relatively high percentage of carbon, was refined in a separate forge.

It is with the first major period of ironmaking, the charcoal fuel stage, that the book is concerned. In his official capacity as historical investigator to the Iron and Steel Institute, London, Dr. Schubert has ranged far and wide, both here and abroad, in search of information on the first 2,500 years of British iron and steel, and an impressive volume is the result of his labours. A glance at the footnotes alone will give some idea of the vast amount of evidence and information which has been sifted in the preparation of the book, and as everyone who has done historical research will know, the quoted sources represent only a small part of the mass which has had to be examined. Historical research consists only too often of a great deal of looking and a small amount of finding. To make an orderly progress through such a maze, to apply the test of historical and technical knowledge to the information discovered, and to accept or reject it accordingly, is a work of high scholarship.

Perhaps it might be argued that there can be nothing simpler than historical writing. Once the facts are settled, is there not only one way to proceed, to arrange them in chronological order and weave the story round them? This, of course, is true; it might be added that the simple formula " Start at the beginning, go on to the end, then stop," is a good basis for writing anything. The danger with a chronological arrangement is that it all too easily becomes a mere catalogue of facts, valuable for reference but deadly dull to read. Dr. Schubert has adopted the chronological arrangement, and has avoided its pitfalls. His story is a fascinating one, simply and adequately told; it is a story, too, of which the British nation has every reason to be proud.

A reader need not possess detailed technical knowledge of iron and steel making processes. The book deals with such matters at considerable length (indeed, it would be a poor effort if it did not), but adequate explanations are provided where necessary. Nor has the serious student been forgotten. The copious footnotes, long appendices and a good index make the book easy to use as a source of reference, and provide a key for further study of the subject if required. For the observant reader who is not profoundly interested in history, the book will provide some intriguing items for reflection. For example, two pairs of tongs made at some time between 150 and 50 B.C. are of a shape and form which could be found in any smith's shop to-day. It always comes as a surprise to find that something is very much older than one imagined.

Similar disclosures occur as the book unfolds the long story of the struggle to produce more and better iron (and steel, for that, too, is much older than is generally realised), always against difficulties and sometimes in the face of tremendous odds. There is a familiar ring in many parts of the story. Our forefathers had to contend with poorer quality ores than most of their contemporaries in other countries; to-day we have the same problem. In the past the shortage of charcoal reached crisis proportions; to-day it is clear that supplies of metallurgical coke can only dwindle as time goes on. Our forebears had to contend with wars and economic upheavals, with great technical changes, with shortages and restrictions and interference from outside the industry, and with many other problems which were not of their own making.

Dr. Schubert shows us how a small and unimportant manufacturing process developed from being little more than domestic in scope, how it increased both its output and its range of products, and how it became mechanised, so setting the stage for the general industrialisation which was to proceed at such a remarkable rate from the late Eighteenth Century onwards.

Because the text was obviously prepared with such painstaking care it is all the more disappointing to find that the production of the book does not quite reach the same standard. It is handsomely printed, well illustrated, and a worthy production in every way except one—there are misprints here and there which just should not have remained undetected. Finally, to come to the text itself, one or two words strike a strange note. For example, surely no blast furnaceman would ever say that an engine was used for " blasting " a furnace (page 333). These are minor points, however, and while it is true that they should have been seen and rectified, they are insignificant when viewed against the solid achievement of the book.

WHAT AILS INDIA?

Surveys of Indian Industries. By BADITHA SRINIVASA RAO. *Oxford University Press, Amen House, Warwick-square, London, E.C.4.* (27*s.* 6*d.*)

The difficulties facing India's Second Five-Year Plan have received a good deal of publicity during recent months. It is therefore appropriate that this, the first volume of a series of articles on Indian industries which have appeared in *The Statesman*, from the pen of its industrial correspondent, should now be published and made available in this country. Unfortunately it seems that many of the articles were written three or four years ago and, therefore, to a large extent they have been overtaken by the publication of the second five-year plan. For instance, in the chapter on the iron and steel industry, reference is only made to the plant being built by Krupp and Demag and no mention is made of the plants being built either by the British consortium or by the Russians.

For this reason, although within the limitations imposed by daily journalism and reflecting as it does the rather undigested views of the industries themselves and of Government planners, this book provides a useful historical background to India's present development;

nevertheless it would be dangerous to treat it as an up-to-date work of reference.

The present volume covers the following industries: iron and steel, non-ferrous metals, automobiles, diesel engines, light mechanical and electrical engineering, coal, electricity, petroleum, chemicals, drugs and pharmaceuticals and fertilisers.

Chapters such as those on the motor-car industry prompt doubts as to whether, in the current industrial plan, the priorities have been fully thought out. With a tiny current market, it is the present intention to stop both the import and assembling of motor cars and commercial vehicles and to concentrate on domestic manufacture, in five or six plants, of a range of vehicles from baby cars to heavy diesel lorries. It is clear, however, that there do not yet exist in India the resources either of raw materials or of component manufacturers to support such a sudden change. It is admitted that supply is already potentially far in excess of demand and the main demand envisaged is in public transport.

The extent to which the various branches of the engineering industry can expand will largely depend on the success of the plans to raise iron and steel output. This has been encouraged in the past by tariff protection and received a fillip from the last war; the biggest producer being the Tata Iron and Steel Company, Limited. Although Tata's are to play their part in the present expansion it is on the new Government owned plants that the main reliance is being placed and the results of their operation will be watched with interest.

Although this book contains a good deal of information about existing firms, government control and taxation, production and imports and exports, it does not, unfortunately, have anything to say about the availability of labour and, in particular, of skilled labour and technical and managerial staff. Finance may appear at present the bottle-neck preventing the fulfilment of India's current plans; but shortage of qualified staff, especially in the intermediate ranks, may well be the determining factor over the next few years.

HUMAN ENGINEERING: A PSYCHOLOGIST'S VIEW

Human Engineering. By ERNEST J. MCCORMICK. *McGraw-Hill Book Company Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.*(8 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (60*s*.)

Human engineering is defined by the author as "the design of equipment and the adaptation of work environment for optimum human use." Historically it owes its origin to the work of psychologists investigating military problems during World War II. Since then it has been practiced, in America, almost exclusively by engineering psychologists still working on military problems, either directly or for firms producing military equipment. With this background it is hardly surprising that there is a military feeling running through the text. The purpose of the book is to explain in simple language to engineers and managerial personnel the research findings which lie behind the design recommendations. It appears to be assumed that the reader is already convinced that human engineering is a good thing, since very little is said to show what benefits, if any, would accrue from its application on the shop floor. Many of the experimental conclusions quoted have not yet been validated in industry and not all of them are of equal importance in the industrial sphere. Yet no guidance is given to the reader on the areas where application is likely to produce most benefits, and much that is of immediate practical value to manufacturing industry is omitted. It is true that Dr. McCormick emphasises more than once that he writes as a psychologist and does not claim that his book is a complete compilation of human-engineering data (in which he is at variance with the "blurb" on the dust cover); but under this title and with the definition he gives of his subject he cannot be altogether excused for omitting fields of such importance to industry as radiant heat, work physiology, fatigue (which is given eight lines), ageing, inspection, training or vigilance, or for omitting practically all the contributions made by researchers outside the United States. Of the 400 references given, only 16 are to British work and one to French. Yet it is in Europe where the greatest co-ordination of scientific disciplines has been achieved, under the name "Ergonomics," and where the application to industry has advanced the farthest. The work of Christensen and his collaborators in Stockholm on tasks in steel works and in the lumber industry; of the Max-Planck-Institut in Dortmund in the engineering industry; of Hopkinson in London on glare; of Singleton in Kettering on problems in the shoe industry; of Grandjean in Zürich on visual tasks; to mention just a few, should find a place in any discussion on the application of psychology, physiology and anatomy to the solution of industrial problems. As it is, the omission of European work makes the exposition of some of the subjects rather uneven and in some instances leads to the drawing of conclusions which are not the best in the light of all the available evidence. Within these limitations Dr. McCormick is to be congratulated on producing a book which is outstanding for its clarity; the material is presented in a way which can be clearly understood and all technical terms are clearly explained. Each chapter concludes with a summary, which often interprets the research findings and makes recommendations.

It is likely that, in Europe at any rate, Dr. McCormick's book will be more useful to students of the subject, be they engineers, psychologists or physiologists, than to industrialists, as a readable exposition of the American contribution to engineering psychology with some physiology and other peripheral subjects as well. It should not, however, be taken as a comprehensive statement of the present status of "fitting the job to the worker" in all its aspects.

NEW BOOKS

A Treatise on the Internal Mechanics of Ball, Tube and Rod Mills. By H. E. ROSE and R. M. E. SULLIVAN. *Constable and Company Limited, 10 Orange-street, London, W.C.2.* (25*s*.)

As has been the case with previous volumes in this series of monographs from the Powder Science Laboratory, King's College, London, the object of the present monograph is to bring together the data concerning some portion of the field of science dealing with powdered materials. In this instance the internal mechanics of ball, tube and rod mills are dealt with. In the light of the authors' experience and researches, the available data have been analysed and the results presented in systematised form.

Second Specialist Conference on Fuel Research. Report of Conference held in London in July, 1956. *Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2.* (1*s*. 6*d*.)

Delegates from official research organisations in the United Kingdom, Canada, Australia, New Zealand, South Africa, India, Rhodesia and Nyasaland, and the Colonies, attended the Second Specialist Conference, held, under the chairmanship of Dr. A. Parker, C.B.E., in London, from July 9 to 16, 1956. The First Specialist Conference on Fuel Research was held in July, 1950. The Second Conference discussed such subjects as existing facilities for training in fuel technology and for carrying out fuel research in the Commonwealth and the possibility of improving and augmenting these facilities. The feasibility of collaboration between the Commonwealth organisations in research work were also discussed and arrangements made to initiate joint investigations in the fields of coke testing, coal "grindability," and petrographical work.

On the Shelf

By Frank H. Smith

A "box" in *Aviation Week* for 27 January is headed "Translation Plan." It tells of the United States Department of Commerce's scheme to compile and distribute translations of available Soviet technical literature. It is scheduled to "publicly distribute" (*sic*) approximately 50,000 abstracts and 10,000 complete translations annually, including articles from 200 important Russian scientific journals. All that remains is to find somebody to read them. In another part of the same issue it is stated that the intention is to set up a centralised establishment to cope with this collection, translation and distribution; i.e. to form "a counterpart to the Soviet Institute of Scientific Information founded in 1953." It will be fun for someone to spend a couple of days translating a Russian article to find that it is a translation of an American article.

I am sure that "On the Shelf" would have a wonderful time at the Phoenix Gallery, 36a St. Martin's-lane, London, W.C.2. There one can see shelves—bookshelves—in a variety of units, self-contained, expanding, open, and glass-fronted, in a range of sizes to suit one-room flats up to large houses. They carry the Standard "kite-mark." A price list and illustrated folder is obtainable from the address indicated.

Pergamon Press have issued a quite attractive catalogue of books and journals published and contemplated by them, obtainable from 4 and 5 Fitzroy-square, London, W.1.

Aviation Age is an American journal that is notable, among other things, for its awkward size. Conover-Mast are the publishers and they have now transferred some of the *Aviation Age* material to *Business/Commercial Aviation Magazine* "designed exclusively for management, operations and maintenance men in business and commercial aviation." It costs 20 dols. a year, from 205 East 42nd-street, New York, 17, U.S.A.

The Society of Motor Manufacturers and Traders Limited, 148 Piccadilly, London, W.1, send out their press releases on sheets headed "The British Motor Industry." That for January 31 announces new standards for the *Handbook of Standards for the British Automobile Industry*, together with a new index. The *Handbook* deals with standards for certain components, specifications for materials, and codes of recommended practice for lighting and signalling equipment. The price is 4 guineas, less 50 per cent to members of the Society, plus 1 guinea to have it maintained up to date.

From America comes No. 1 of volume 1 of *The Physics of Fluids* (January-February, 1958). Published by the American Institute of Physics, 335 East 45th-street, New York, 17, its subscription price is 11 dols. The Air Force Office of Scientific Research and the Office of Naval Research are co-operating and giving financial assistance to the journal. An unusual feature is that the volume title-page appears as the title page of the first number thus indicating how many numbers go to make the volume.

When Professor R. H. Macmillan came to prepare the inaugural lecture he delivered at the University College of Swansea last December, he found that his own subject—automatic control—had already been the subject of two inaugurals a short while before. His second choice "The Place of Engineering in University Education," had been the subject of the Third Graham Clark Lecture. This combination of circumstances led to our good fortune because Professor Macmillan finally spoke on "The Communication of Ideas," and produced a lecture on report writing that should take its place with the more comprehensive works on the art. He lays great emphasis on clarity and simplicity and his own work is a model of those two virtues. There are only 25 pages and his English is so easily understandable that not one sentence need be read twice.

Design

RUNNERS OF EXPERIMENTAL TURBOMACHINES*

Defining Vane Shapes

By Leslie Young, B.SC.(ENG.)†

A design procedure is proposed whereby flow surfaces of revolution defined by meridional streamlines are transformed conformally into planes. The vane shapes and thickness functions for each flow surface are defined by mathematical functions in the transformed plane. By this means specified vane shapes can be used in runners of arbitrary form, and the effect of systematic variations studied. The procedure is similar to that already in use for axial flow runners, which is in fact a limiting case. It is suggested that existing methods of theoretical flow analysis could be extended to cover cases of interest to hydraulic engineers, and that preliminary studies of this nature could reduce experimental labour. The design method is particularly suitable for such treatment.

To conduct experimental investigations into the performance of turbomachinery it is, among other things, desirable to specify completely

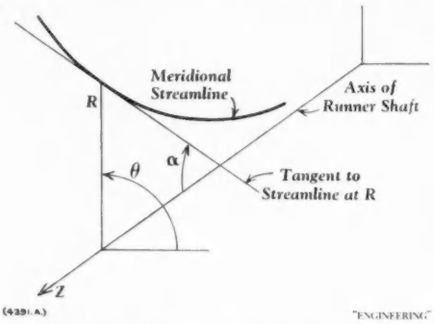


Fig. 1 Definition of cylindrical co-ordinate system.

their geometry, and to have a method whereby this may be varied in some systematic way. The runner vane shape is of particular importance, especially in mixed-flow machines, where the vanes are three-dimensional surfaces.

At present it is possible only in the case of axial-flow machines to define runner vane shapes in a systematic way. Here various sections are specified by means of camber line and thickness function, in the manner adopted for aerofoils, and the design method consists essentially of determining suitable vane shapes on concentric cylindrical surfaces taken through the runner, from performance data available for the specified profiles.

PROPOSED DESIGN METHOD

No such guide exists for the design of vanes for mixed flow runners. Usually the vane inlet and outlet angles are determined from empirical data, and the designer completes the vane surface between inlet and outlet in a more or less arbitrary way. Taking three of the popular methods: development on a cone,[1] " error triangles "[1] and graphical transformation,[2] we see in each case that it is left to the designer's skill and judgment to complete the vane shape. While this is undoubtedly satisfactory in many cases, problems may arise, and so far as research work is concerned there is little possibility of systematic relationship between various runner designs. It is the purpose of this note to suggest an extension of existing design methods for mixed-flow runners which will be comparable with that used for axial-flow machines.

The suggested method for design depends on the use of a conformal transformation, as first proposed by Prasil and developed by Wislicenus,[2] and later employed for theoretical investigations on flow in compressors at the N.A.C.A. It may be summarised as follows:—

(*a*) The overall runner size is determined for the given design duty, and the mean vane outlet angle found.

(*b*) The hub and shroud shapes are specified, preferably by means of simple mathematical curves (for example, parabolic or cubic arcs).

(*c*) A number of meridional streamlines are calculated from potential flow theory.

(*d*) The calculated streamlines are used to define meridional flow surfaces of revolution. These three-dimensional surfaces are transformed conformally to plane surfaces.

(*e*) The vane camber lines and thickness functions are specified for each flow surface by mathematical functions in the transformed plane. The necessary conditions which must be fulfilled are the slope and position of the camber lines at inlet and outlet.

(*f*) The vane shapes are transformed back to the meridional flow surfaces of revolution, so that the true vane shapes and sections may be determined.

In the case of axial-flow machines the meridional flow surfaces of revolution are cylinders concentric with the runner axis, and the design procedure for mixed-flow and axial-flow runners becomes exactly the same. To show further the possible advantages and limitations of the method, the various steps will be considered further:—

Overall Runner Size.—It is assumed that sufficient information is available from past experience to enable the main proportions, such as runner inlet and outlet diameters and the mean vane outlet angle, to be selected for particular design conditions. Analysis of previous results can be presented in a manner such as that of Stepanoff[1] to facilitate the procedure. Investigation may show improvements on existing practice, which can then be incorporated in the primary design data, but the stock of empirical knowledge is at present quite sufficient to provide a sound starting point.

Hub and Shroud Contours.—Unsatisfactory pressure and velocity distributions at the hub and shroud may give rise to separation and high losses. Tyson[3] has studied flow between the shrouds, and shown that satisfactory shapes can be determined from potential flow theory, either by calculation or by use of the electrical analogy. Smith and Hamrick[4] give full details of a method for the design of hub and shroud profiles for impellers with a given vane shape. For the purpose of this note, the vane shapes will be assumed not to be known at this stage, but it will usually be a sufficiently good approximation to assume radial blades, or some other plausible shape. If desired, the calculations can be repeated for the vane shape as found subsequently, and the results used for a second determination of the vane shape. The method has the advantage that a desired average velocity distribution at either hub or shroud can be chosen to be least conducive to boundary-layer build-up. Thus, suitable means are available to settle the hub and shroud profiles on a rational basis. It is suggested that where possible simple mathematical functions are used to define them (such as, elliptical, parabolic or cubic arcs).

Calculation of Meridional Streamlines.—The calculation of potential flow through a three-dimensional rotating impeller passage is a difficult and laborious task. As an approximation, quasi three-dimensional solutions have been suggested in which the meridional streamlines have been calculated on the assumption of axial symmetry (i.e., no velocity variation from blade to blade) and the blade-to-blade velocity distribution calculated on flow surfaces of revolution defined by these streamlines.[5, 6, 7, 8] Ellis and Stanitz[9] have compared results obtained by

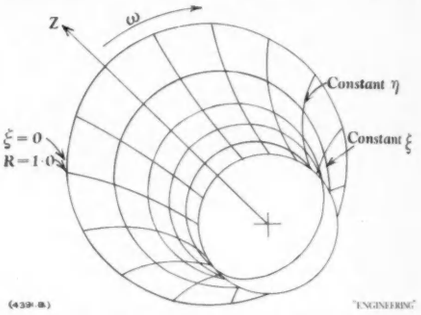


Fig. 2 Lines of constant flow ξ and η on flow surface of revolution.

this method with a complete three-dimensional solution and conclude that the approximation may be sufficiently good for engineering analyses.

If the hub and shroud profiles have been found by the method of reference,[4] the required streamlines will already be available from those calculations. If some other method has been used, they may be calculated in the way proposed by Hamrick, Ginsburg and Osborn.[6] Again it should be noted that a knowledge of the actual vane shape is needed for these solutions, but some reasonable assumption for the shape should be satisfactory for a first approximation. This can be corrected if necessary by recalculation after the true vane shape has been found, and a second corrected vane shape determined. Calculation of the streamlines will give the velocity variation from hub to shroud, and the vane inlet angles can be determined from the required design operating range once the position of the inlet edge has been found.

Transformation of Meridional Flow Surfaces of Revolution.—The hub and shroud profiles and the meridional streamlines are most conveniently described in terms of the cylindrical co-ordinates R, Z, θ specified in Fig. 1. They define flow

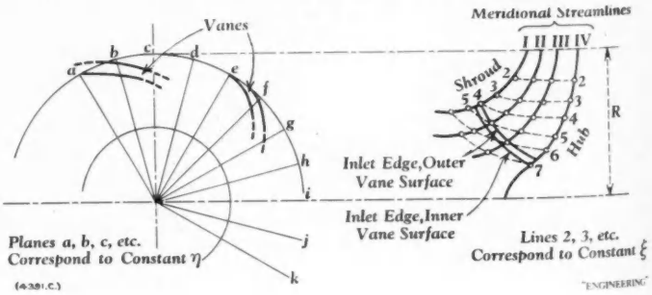


Fig. 3 Meridional streamlines and lines of constant transformed co-ordinates on runner section.

* Crown Copyright Reserved.

† Fluid Mechanics Division, Mechanical Engineering Research Laboratory, East Kilbride.

surfaces of revolution typically as shown in Fig. 2. The following transformation of co-ordinates is then applied:—

$$d\xi = \frac{1}{\Delta\theta \sin\alpha} \frac{dR}{R}$$

$$d\eta = \frac{d\theta}{\Delta\theta}$$

where $\Delta\theta$ is the angular spacing between successive runner vanes.

Integration by graphical or numerical means (α being obtained graphically or by calculation) gives ξ as a function of R. It is convenient, as will be seen later, to relate the transformed planes for each flow surface. To accomplish this, the maximum runner diameter is taken as unity and ξ arbitrarily as zero (or 1) at this value of R for all the flow surfaces. η is, of course, equal to $\frac{\theta}{\Delta\theta}$. The transformation is conformal, and is the rigorous mathematical equivalent of the graphical procedure described by Wislicenus.[2] Fig. 3 shows the appearance of lines of constant ξ and η in radial and axial runner sections.

Specification of Vane Shape.—The vane camber lines and thicknesses are to be specified in the ξ, η plane for each meridional flow surface of revolution. To ensure smooth curvature of the inlet and outlet edges of the vanes, the points representing the terminations of the vane camber lines must lie on smooth curves in the ξ, η plane. It is therefore convenient to consider all the camber lines on a single ξ, η diagram as shown in Fig. 4. The vane terminations for each flow surface considered are determined at the designer's discretion in the axial section through the runner (Fig. 3) and the corresponding values of ξ calculated in the transformed plane. It has generally been found in practice that the best results are obtained when the vane edge meets hub and shroud approximately in a right angle, and the shape in the axial section should be chosen to allow this.

A value of $\eta = 0$ is taken for the vane inlet edge at the hub and a smooth curve drawn from this point in the ξ, η plane to intersect the previously calculated ξ values for the other flow surfaces, which thus determines completely the vane edge in the transformed plane. The simplest possible function should be used which will give a satisfactory vane edge, (such as a circular, elliptical or parabolic arc). A value must be chosen for the vane length at the hub (from previous experience in the first instance at least) and the corresponding value of η at the vane outlet edge found via the true radial view of the runner. The ξ co-ordinate is already available from the overall runner dimensions. With the position of the vane outlet edge at the hub fixed in this way, the trace of the outlet edge may be specified in the ξ, η plane in the same way as for the inlet edge.

Knowledge of the hub to shroud velocity distribution obtained in calculating the meridional streamlines, and of the vane inlet shape in the axial section, enables the vane inlet angle for each meridional flow surface to be found. It may be necessary to take into account the effect of blade thickness and the requirements for radial equilibrium[10] but, until experimental evidence is available to warrant this refinement, it is suggested that they be ignored. The vane outlet angle at a specified radius will in general be known from the information on overall dimensions based on previous experience referred to above. The outlet angles at each meridional flow surface are then easily obtained from the hub/shroud velocity distribution and vane outlet edge shape.

Four properties of the vane section on each meridional flow surface are now known: namely, position and angle at inlet and outlet. The vane camber lines must therefore be specified to fulfil these necessary conditions. This is accomplished by choosing mathematical functions in the ξ, η plane which meet the requirements. In the first instance it is suggested that the simplest possible function be used. Experience may show that requirements for blade loading, continuity of pressure distributions, etc., require further conditions to be imposed which necessitate more complex functions. There should be no difficulty in accomplishing this. Once the camber lines have been fixed, any desired thickness function can be specified in the ξ, η plane. Only experience can show the best type to use, but it will be logical at first to consider those which have been successful in axial-flow pumps or turbines. If it is desired to investigate a family of runners of different specific speeds it should be possible to determine hub and shroud shapes having the same non-dimensional velocity distributions, and meridional streamlines such that the same mass flow passes between adjacent streamlines. The vane thickness functions are then taken as identical for all the runners on the corresponding streamlines.

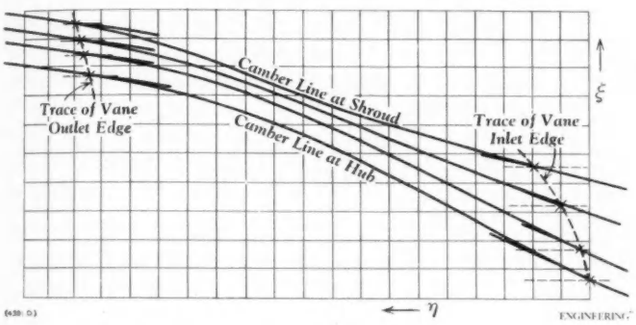
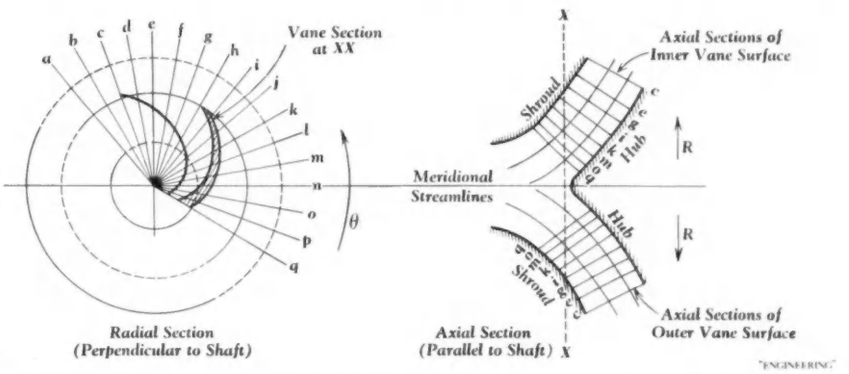


Fig. 4 (left) Vane camber lines in transformed plane.

Fig. 5 (below) Derivation of vane sections.



Determination of True Vane Shape and Sections.—Vane shapes having been found in the ξ, η plane, reversal of the transformation enables the true shapes to be plotted on axial and radial sections, as illustrated in Fig. 5. The values of R for each side of the vane at each flow surface for constant values of θ (obtained from ξ values at constant η) are plotted in the axial section and joined by smooth curves. The vane sections can then be plotted in the radial view by taking appropriate sections through the axial view.

The planes $a\,b\,c\ldots$ in Fig. 5 represent constant θ values corresponding to constant η values. The value of ξ for each meridional flow surface at each η value gives values of R which are plotted on the appropriate streamline in the axial section, inner and outer vane surfaces being dealt with separately. Corresponding points are joined by smooth curves to give axial vane sections. Taking cutting planes such as XX circular projection to the radial section gives the radial vane sections.

Adoption of a design method of the type outlined above would enable experiments on specified vane shapes to be made, with the object of providing information similar to the cascade data available for axial-flow machinery. The experiments should preferably be made on rotating machines, since it is known that considerable corrections must be made to aerofoil and cascade results in applying them to the design of axial-flow pumps. The factors which need systematic investigation appear to be:—

(*a*) Effect of vane camber line shape and thickness function on the pressure and velocity distribution at the vane surface. These affect cavitation performance and also efficiency since adverse velocity and pressure gradients will lead to boundary-layer separation.

(*b*) Effect of vane inlet edge shape and position on cavitation performance and efficiency. This is considered separately from (*a*) because there may be special corrections to the design occasioned by the finite blade thickness, radial equilibrium requirements and the effects of hub and shroud boundary-layer interference.

(*c*) Effect of hub and shroud shapes on all aspects of performance.

(*d*) Effect of number of vanes on performance.

(*e*) Effects of vane outlet edge shape on performance.

There is, of course, a large amount of information already in existence on some of these points, notably (*c*), (*d*) and (*e*). More information on (*a*) and (*b*) is needed, however, if performance of the higher specific speed machines is to be improved, particularly so far as susceptibility to cavitation is concerned. Thus, a great advantage is gained by designing experimental machines to a positively specified vane shape.

The quasi three-dimensional potential flow solutions already referred to under the heading "Proposed Design Method" offer the possibility of calculating the flow patterns in a runner passage to a reasonable degree of approximation, though some modifications may be necessary to adapt them to the type of machine used in hydraulic applications. In particular, the approximations are not generally good in the vane inlet edge region, which is of great interest, though Kramer[11] has shown how a refined solution can be applied to this area once the general solution has been calculated. If digital or analogue computers could be used to obtain solutions, a large number of possible camber lines and thickness functions could be examined theoretically, and only those showing promise used for experiment. This would reduce the experimental effort considerably. Since the solutions are obtained in the transformed (ξ, η) plane, it is again an advantage to specify vane shapes by functions in this plane.

CONCLUSIONS

1. A design method is described by means of which vane shapes can be completely specified for turbomachine runners of arbitrary form, applicable to pumps, compressors, or turbines.

2. The use of positively specified vane shapes

Continuing **Design**

MECHANISM EFFICIENCY NOMOGRAMS

By R. H. Macmillan, M.A.
Professor of Mechanical Engineering, University College of Swansea.

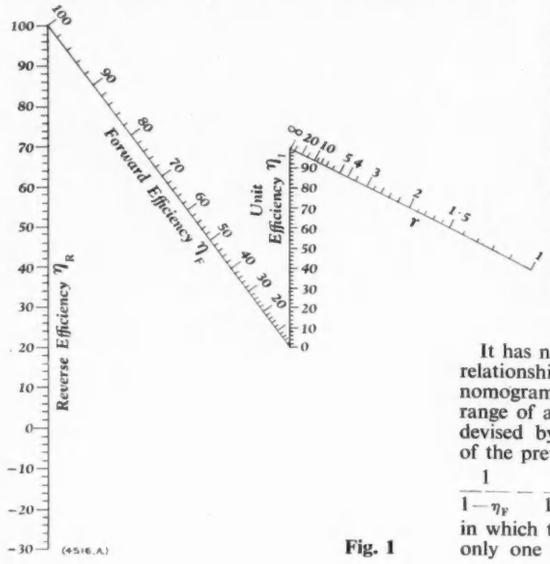


Fig. 1

In an article published in the February 15, 1957, issue of ENGINEERING, relations were derived between four variables connected with linear mechanisms:—η_F, the forward efficiency; η_R, the reversed efficiency; η_1, the unit efficiency; and r, a measure of the velocity ratio. The expressions are valid for a rather general class of mechanism, whose efficiency is sensibly independent of the power transmitted, within the range of loads and speeds considered. In the article cited the relations between these variables were plotted on a series of graphs.

It has now been found possible to express the relationships completely by means of the nomogram of Fig. 1, which covers the full range of all the variables. This chart has been devised by expressing equations (12) and (17) of the previous article in the form

$$\frac{1}{1-\eta_F} - \frac{1}{1-\eta_R} = \frac{r-1}{r+1} = 1-(1-\eta_1)\left(\frac{1}{1-\eta_R}\right),$$

in which the variables have been separated and only one function of each variable appears.

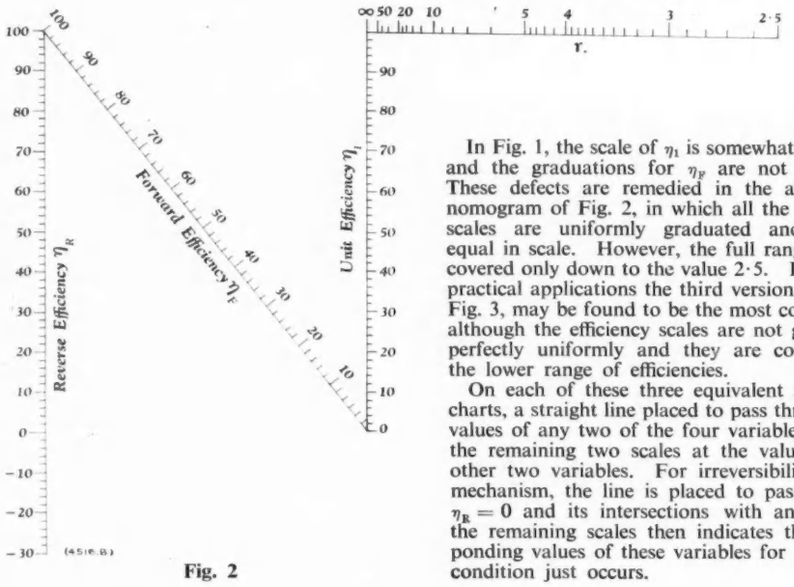


Fig. 2

In Fig. 1, the scale of η_1 is somewhat cramped and the graduations for η_F are not uniform. These defects are remedied in the alternative nomogram of Fig. 2, in which all the efficiency scales are uniformly graduated and almost equal in scale. However, the full range in r is covered only down to the value 2·5. For many practical applications the third version, given in Fig. 3, may be found to be the most convenient, although the efficiency scales are not graduated perfectly uniformly and they are confined to the lower range of efficiencies.

On each of these three equivalent alignment charts, a straight line placed to pass through the values of any two of the four variables will cut the remaining two scales at the values of the other two variables. For irreversibility of the mechanism, the line is placed to pass through $\eta_R = 0$ and its intersections with any pair of the remaining scales then indicates the corresponding values of these variables for which the condition just occurs.

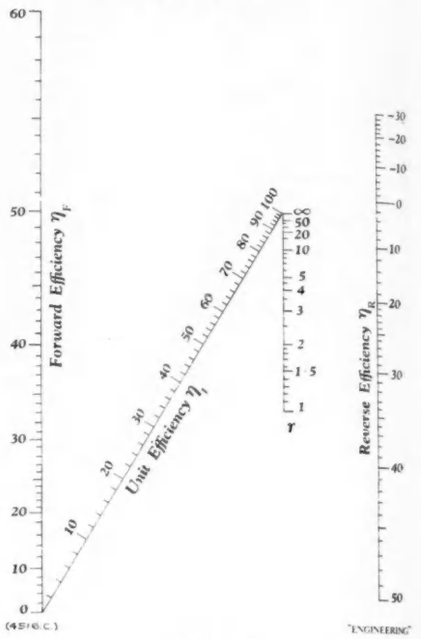


Fig. 3

SUSPENSION PIPE-BRIDGE

In our issue of January 10 last, on page 49, we published a photograph of a novel form of suspension pipe-bridge which carries a high-pressure gas main over the River Danube in Austria. At the time of publication few details were available to us, but an Austrian reader has sent us the following information.

The bridge is a true suspension bridge with inclined suspension webs. It has a span of 320 metres (not the mere 200 ft intimated in our earlier note) and its anatomy is best understood by referring back to the photograph. The pylons are Y-shaped and the pipe is carried in a flat parabolic curve over the river by two carrier cables fixed from the heads of the pylons and gathered to the pipeline at mid-span; for intermediate support, there are stirrups at 10·3 m intervals with wire suspenders fixed to the carrier cables and interconnected by cross-wires. At the pylons the pipeline is supported at the level of the top of the vertical leg of the Y. Alongside the pipe, throughout its span across the river, are twin tensioned cables which, together with the bracing cables from the pylon heads, are anchored to blocks 93 m behind the pylons. The heads of each pylon are 37·5 m above the foundation blocks and 50·5 m apart; the carrier cables have a dip (measured in the plane of the suspension web) of 35 m and the tensioned cables a rise of 5 m. The weight of the pipe, which is of 400 mm nominal diameter, is 35·5 (short) tons, and the total weight of steel in the bridge 209 tons. The pylons themselves are built of steel-framed box members of relatively light construction. It is claimed that, even in high winds, excessive oscillation is quite impossible. In the navigable section of the river there is 9 m clearance below the structure at high water level.

The pipeline, part of a project undertaken by the Austrian Mineral Oil Organisation, is intended to operate at a gauge pressure of 64 atmospheres, conveying natural gas to Vienna and Lower Austria and, by an extension over the Semmering Pass, to industrial undertakings in Upper Styria.

Continuing **Runners of Experimental Turbomachines**

enables the effects of systematic variations to be examined both theoretically (by an extension of established methods) and experimentally.

3. The assembly of a body of data on specified vane and runner shapes should be of great assistance in design.

REFERENCES

[1] A. J. Stepanoff. "Centrifugal and Axial Flow Pumps." New York: Wiley, 1948.

[2] G. F. Wislicenus. "Fluid Mechanics of Turbomachinery," New York: McGraw-Hill, 1947.

[3] H. N. Tyson. "Experimental Study of Flow Between Centrifugal Pump Shrouds." California Institute of Technology, Hydrodynamics Laboratory, Report No. E-19.6, 1954.

[4] K. J. Smith and J. T. Hamrick. "A Rapid Approximate Method for the Design of Hub-Shroud Profiles of Centrifugal Impellers of Given Blade Shape." *N.A.C.A. Technical Note* 3399, 1955.

[5] G. O. Ellis, J. D. Stanitz and L. J. Sheldrake. "Two Axial-Symmetry Solutions for Incompressible Flow through a Centrifugal Compressor with and without Inducer Vanes." *N.A.C.A. Technical Note* 2464, 1951.

[6] J. T. Hamrick, A. Ginsburg and W. M. Osborn. "Method of Analysis for Compressible Flow through Mixed-Flow Impellers of Arbitrary Design." *N.A.C.A. Report* 1082, 1952.

[7] J. D. Stanitz and G. O. Ellis. "Two-Dimensional Flow on General Surfaces of Revolution in Turbomachines." *N.A.C.A. Technical Note* 2654. 1952.

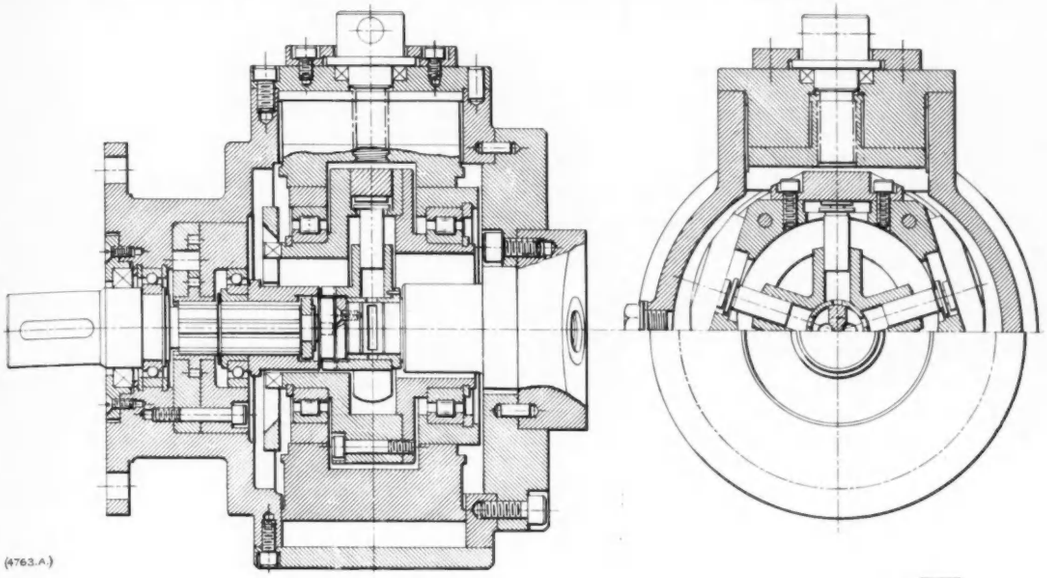
[8] Chung-Hua Wu, C. A. Brown and V. D. Prian. "An Approximate Method of Determining the Subsonic Flow in an Arbitrary Stream Filament of Revolution Cut by Arbitrary Turbomachine Blades." *N.A.C.A. Technical Note* 2702, 1952.

[9] G. O. Ellis and J. D. Stanitz. "Comparison of Two- and Three-Dimensional Potential-Flow Solutions in a Rotating Impeller Passage." *N.A.C.A. Technical Note* 2806, 1952.

[10] J. D. Stanitz. "Effect of Blade-Thickness Taper on Axial-Velocity Distribution at the Leading Edge of an Entrance Rotor-Blade Row with Axial Inlet, and the Influence of this Distribution on Alignment of the Rotor Blade for Zero Angle of Attack." *N.A.C.A. Technical Note* 2986, 1953.

[11] J. J. Kramer. "Theoretical Analysis of Incompressible Flow through a Radial-Inlet Centrifugal Impeller at Various Weight Flows. II.—Solution in Leading-Edge Region by Relaxation Methods." *N.A.C.A. Technical Note* 3449, 1955.

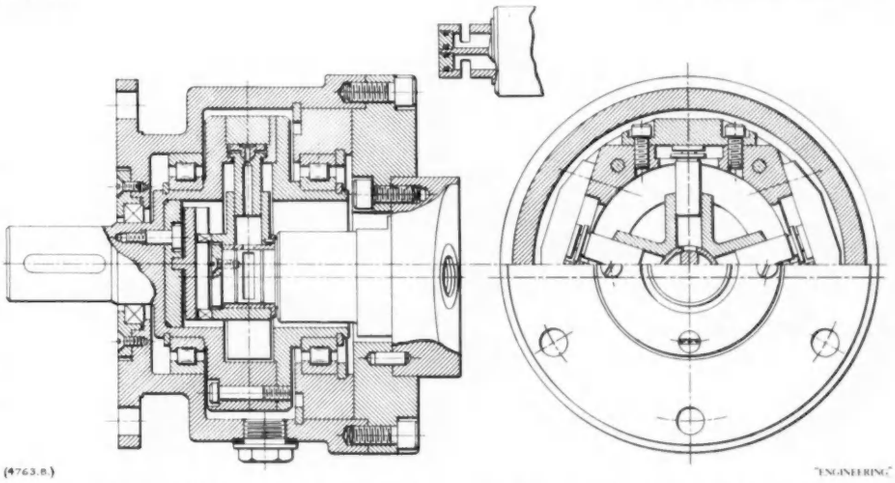
HIGH EFFICIENCY HYDRAULIC TRANSMISSION



(4763.A.)

Fig. 1 (left) Section through variable delivery pump. The degree of eccentricity of the track, which controls the delivery, can be varied by a number of means.

Fig. 2 (below) In the case of the fixed delivery model, pump and motor are identical.



(4763.B.) "ENGINEERING"

A HYDRAULIC transmission equipment with a high operating efficiency has been developed by N. J. Tatham and Company, Limited, Haywards Heath, Sussex. It is intended eventually to make the equipment available either as a self-contained infinitely variable gear, or as separate hydraulic pumps and motors, in both fixed and variable delivery versions.

The manufacturer's aim has been to produce units which combine simplicity and low cost with high efficiency and long trouble-free life. Tests show a volumetric efficiency figure for either pump or motor of 98·6 per cent at 3,000 lb/sq. in. using Shell Tellus 29 oil at 55° C. The mechanical efficiency for the motor is stated to be about 95 per cent at full load, and that of the pump somewhat higher, giving an overall transmission efficiency of the order of 90 per cent. The noise level is low and varies little with load.

In general principle the transmission is quite orthodox, and consists of a variable displacement rotary radial-piston pump feeding an hydraulic motor of similar construction, in a closed circuit system. High performance and constructional simplicity have been sought through detail design; the arrangement adopted gives a fully reversible drive, with speed adjustable from maximum in one direction through zero to maximum in the opposite direction. The pump and motor are similar except that as used in the transmission, delivery control would most often be fitted to the pump only; delivery control can however be equally well applied to the motor, this being advantageous for transmissions which have to deliver a constant horsepower at a variable speed; the more usual system of varying pump delivery only gives optimum results when handling a constant torque at varying speeds.

The pump and motor are arranged back to back, and rotate on a double-entry pintle, which provides a very short straight path for the oil. Relief valves are built in, to prevent overloading particularly when decelerating a high inertia load. A closed circuit requires replenishment of leakage losses, and this is effected by a small gear pump delivering through a pair of non-return valves at 300 lb/sq. in. (this "base pressure" helps to minimise elasticity due to entrained air bubbles in the oil). The transmission casing forms a sump, from which the gear pump takes its suction.

Fig. 2 is a section of a fixed-capacity motor (or pump). There are five radial pistons which bear against pads having spherical seats to allow for misalignment. The pads in turn bear against the flat surfaces of blocks bolted to the rotating track. A separate drive through an Oldham coupling rotates the cylinder block in synchronism with the track to avoid side loading on the pistons, but the full torque passes directly from the track to the drive shaft. The pistons are drilled axially to permit pressure lubrication of the bearing pads so that an oil film is continuously maintained. Precautions have also been taken to balance the pressures at the interface of the pintle and the rotor to avoid scoring or possible seizure. Prolonged overload tests were carried without any sign of marking.

The arrangement of the variable-delivery pump is shown in Fig. 1. This differs from the fixed-delivery unit in that the track bearings, instead of being fixed, are carried in rings bolted to a pair of sliders working in a cross bore in the pump casing, thus enabling the eccentricity of the track (relative to the pintle) to be varied; it is proposed to provide a choice of hand-wheel control, push-pull servo-boosted control, or various forms of automatic governing. In the variable-delivery unit the drive shaft can no longer be solid with the track since the latter is movable; the shaft is therefore made concentric with the pintle, and drives the track through an Oldham joint.

The units have been designed for a maximum continuous working pressure of 3,000 lb/sq. in., but can be overloaded to 4,000 lb/sq. in. for short periods.

4,000,000 HOURS BY DART TURBOPROPS

The Dart, the world's first propeller-turbine engine, has now flown more than 4,000,000 revenue hours powering the Vickers Viscount on the world's air routes. It is perhaps unnecessary to recall that the Dart is made by Rolls-Royce Limited, Derby.

The Dart engine started service with a life between overhauls of 400 hours, and within 18 months the Air Registration Board extended the life to 1,050 hours. This was achieved at a time when the Dart was the only gas-turbine in airline service. Since then, the overhaul life has gradually been extended and lives of up to 1,800 hours have been approved, and engines have been run to over 2,000 hours on a trial basis with a view to further extending overhaul life.

The success of the Dart in the Vickers Viscounts, and its power development while maintaining reliability, have led other airframe manufacturers to adopt the Dart for their new designs. The Fokker Friendship, which is also being built under licence in the United States by the Fairchild Airplane Corporation, is powered by two Darts. The only military application of the Dart is in the Breguet Alizé ordered for anti-submarine duties with the French Navy. Other aircraft which will be powered by the Rolls-Royce Dart are the Armstrong Whitworth 650 Freightercoach, the Handley Page Herald, and the Grumman Gulfstream.

Special Article

SPEED AND INDUSTRIALISATION—AND POPULATION

Although there seems to be no technical impossibility in the construction of an air-liner to fly at supersonic speeds in the 1960's, it does seem to be unlikely that any of the world's airlines, after re-equipping in the next year or so with fleets of costly new subsonic jet-liners, will have the money to purchase supersonic aircraft before the 1970's. By that time, in the opinion of Sir George Edwards, managing director of Vickers-Armstrongs (Aircraft) Limited, the operating costs of the supersonic air-liner should be of the same order as those of the 600 mile/h machines—as forecast at present. Sir George was speaking recently in his capacity as president of the Royal Aeronautical Society on the occasion of the Presidential Address; and the culminating point of the address was that Britain—who to-day holds all the Western hemisphere's operating experience of turbine-powered transport aircraft, now amounting to several hundred million miles—should stake a strong claim in the field of supersonic civil travel.

In the course of his lecture, Sir George produced some illuminating illustrations on the relationship between industrialisation, population and the speed of travel. Taking, as a basis, the maximum distance that could be covered in a day's journey (12 hours): at the end of the Eighteenth Century this amounted—perhaps optimistically—to 75 miles by stage coach. Came the Industrial Revolution, and by 1895 the 12-hour distance had jumped up to 550 miles overland. Surface transport had made little progress in speed by 1920, and air travel had barely started. By 1930 the 12-hour distance was up to 760 miles, by 1940 to 1,260 miles, and by 1960, when the big sub-sonic jet-liners will be operating, it will be up to 5,500 miles. The interesting point is the amount of the world that will still remain uncovered by a 12-hour journey—even in 1960 onwards—but which will fall into the scope of a day's travelling with the advent of the supersonic air-liner. This is an important point because, as Sir George has discovered from a general study of business travel, when a destination gets beyond the 12-hour journey circle, the journey incidence falls sharply—and of the total business journeys from London, only one-sixth penetrate to the more distant areas such as South America, Australasia, the Far East and a large part of South-East Asia.

In Fig. 1 is depicted graphically the increase in journey time, and the increase in population over the years. "It is clear," Sir George deduces, "that the increase in industrialisation, which came with the Industrial Revolution, in turn brought about an increase in population, and a greater demand for more and faster transport. This increase in travel stimulated business and in turn increased industrialisation and with it the population. . . . Put simply, increasing speed in transport has been the essential hand-maiden to increasing development all over the world and . . . the only medium in which speed can continue to increase is in the air." Pursuit of speed for its own sake, however, is unhealthy; up till now, higher speeds in the air have been accompanied by better economy and efficiency, and any reversal of that trend would set back civil aviation.

Considering the progress of the aeroplane, Fig. 2 shows the speed trends throughout the years—the top curve representing world speed records, and the lower curves bomber aircraft and propeller-driven transports respectively, with two short curves representing the jet transports—the Comet and the TU 104. The surprising thing revealed here is the way in which the slope of the speed-record curve steepens abruptly with the advent of the supersonic air-frame. From these curves, Sir George has extrapolated to give the results shown in Fig. 3. The bomber curve is extended on the supposition that a supersonic bomber capable of flying at Mach 2·5 could be built by 1965; and the propeller-transport curve on the assumption that propeller-driven aircraft are unlikely ever to cruise at speeds above 500 mile/h. For the jet-transport curve, a "speed plateau" of 600 mile/h has been assumed to extend throughout the 1960's, for reasons already given; with a sharp change in the slope of the curve—in accordance with the speed-record curve—as the supersonic regime is entered, and the whole world is within reach in a 12-hour journey. What Sir George has not extrapolated—perhaps very wisely—is the world population curve, which, if his thesis is correct, may be expected to shoot up in a truly frightening manner as we enter the regime of the supersonic air-liner.

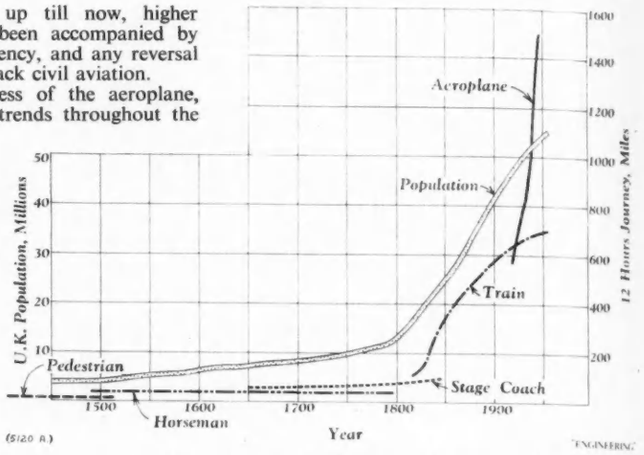


Fig. 1 Twelve hours journey, and the United Kingdom population, over the centuries.

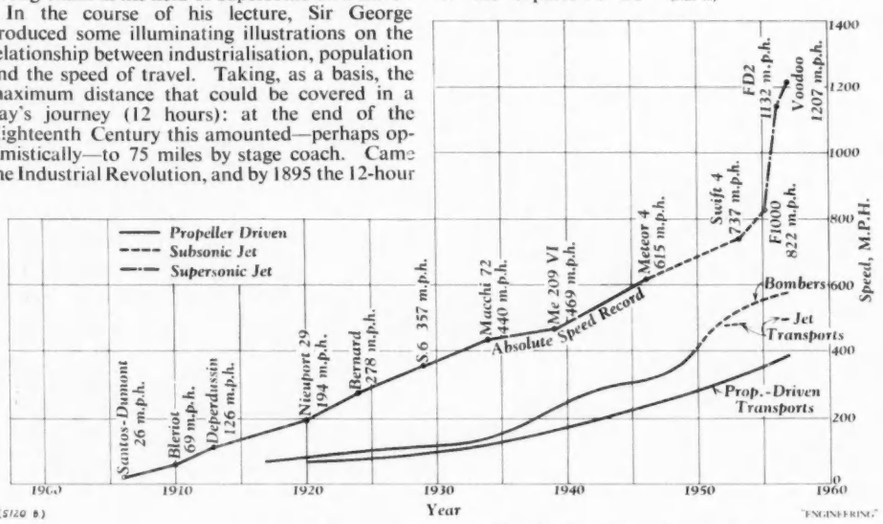


Fig. 2 Speed trends over the years.

TRANSONIC FLIGHT : FILM

Following Sir George Edwards' Presidential Address to the Royal Aeronautical Society, was the first showing of the second part of Shell's "High Speed Flight" colour/sound film, which deals with the problems of the transonic speed range. (Part 1 is concerned with "Approaching the Speed of Sound," and Part 3, "Supersonic Flight," is still in production.) The film shows how instability troubles arise from shock-induced separation, and the design methods developed to lessen the effects of the shock stall. The film is of considerable general technical interest, and is available gratis on loan to responsible organisations, either on 35 mm or 16 mm film, from the Petroleum Films Bureau, 29 New Bond Street, London, W.1.

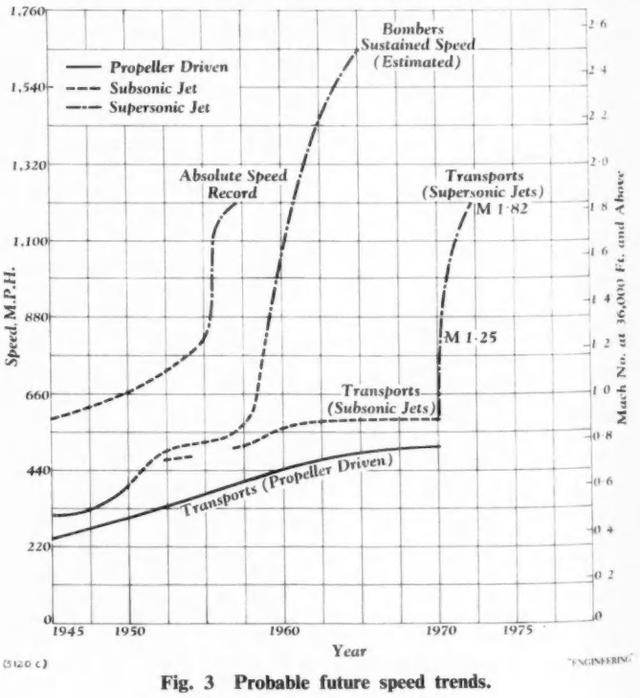


Fig. 3 Probable future speed trends.

Production

MAKING SCIENTIFIC GLASSWARE

Quickfit and Quartz, Limited, were founded in 1934 to produce a range of standardised interchangeable laboratory and industrial glassware, based on improved product design and the use of mechanised production methods. In 1946 the company moved from the Birmingham works of their parent organisation, the Triplex Safety Glass Company, Limited, to Stone, Staffordshire, and here the process of development, both of products and of manufacturing methods, has continued. A large scheme of re-organisation and re-equipment is now virtually completed and as a result production at the works has been increased by as much as from four to six times.

Mechanisation of manufacture of a specialised product is not always as simple as it might seem, for it often happens that there is no suitable production machinery on the market, and the first step is to design the necessary machines. Quickfit and Quartz have had to undertake this sort of work for a number of years, and a small but well-equipped toolroom is an essential feature of the Stone factory. On the other hand, some well-tried items such as conveyors, can be bought, and other equipment can be modified from its original purpose to suit a particular need. Items of all three types have been incorporated in the layout at Stone.

Production is divided into two main groups, laboratory glassware and industrial plant, the former being generally of a simpler nature, while the latter is often of complicated shape, and custom built for particular requirements. The Quickfit and Quartz range of laboratory glassware is very well adapted to mechanised manufacture, and several special-purpose machines are used in this department of the works at Stone.

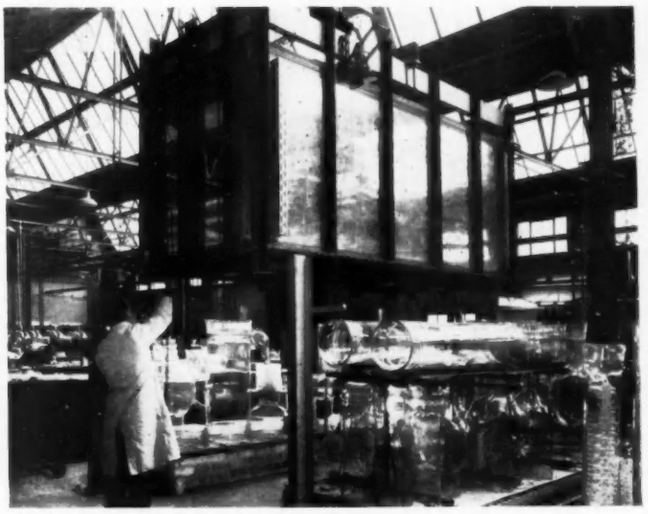
Laboratory ware is made from glass tubes, which are received in 5 ft lengths and cut off in pieces as required in the stores. A machine has been designed and built for this purpose by Quickfit and Quartz, and both ends of the cut-off pieces are edge-fired or fused to form a rounded edge, automatically, as the cutting proceeds.

Shaping of the laboratory ware is by oxy-coal gas flame in specially-designed lathes, and 48 of these machines, in four lines of 12, are installed in the forming department. Two flat belt conveyors extend the length of the shop, each conveyor serving two lines of lathes, and deliver the formed components to an inspection department, running at right angles to the production shop. Cut tubes are delivered to the lathe operators in trays and each operator loads his finished products in wire trays on to the conveyor.

Control of the conveyor is from the inspection department, the belt being stationary until the inspectors require more work, when the conveyor is started to bring as many trays as necessary into the department. Stop buttons are provided in the production shop for emergency use only. Inspection is followed, in the same department, by the transference of the company's trade mark and any other information required on the products, which then pass, in trays, to a short length of roller conveyor leading to a conveyor type electric lehr, built by Royce Electric Furnaces Limited, Walton-on-Thames. Annealed glassware then moves to the next department, where the joints are ground as described in the following paragraph.

Laboratory glassware at the works of Quickfit and Quartz, Limited, is handled by conveyor.

Joint grinding, to fine limits, is done by special machines designed and built by the company.



Large industrial glassware is annealed in an electric furnace which can be lifted off by an overhead hoist.

Both conical and spherical joints are produced, the grinding being at one time done by hand. A small hand-grinding section is still retained, for short run and special work, but most of the grinding is now done by special-purpose machines designed and made by the company. A high degree of accuracy is obtained from these machines, which are semi-automatic in operation, profile accuracies to within 0·0001 in. being a normal requirement. The machines each have six grinding spindles, three of which are used for roughing and three for finishing. Operation except for loading and unloading, is entirely automatic, the machine stopping when the grinding cycle is complete. Inspection follows the grinding operation, and the glassware is then ready for packing and dispatch to its destination.

Glass vessels, piping and other components are used extensively in the chemical industry, and the Stone factory produces a large variety of items for this purpose, some of them, such as heat exchangers, being of complicated form. This type of equipment, being required in smaller individual batches than laboratory ware, does not lend itself to movement by conveyor, but the fabricating machinery, which is of special design, makes the best possible use of mechanical devices.

A bottleneck in the production of glassware of this type used to be the necessary annealing, and as the continuous lehr is not suitable for the heavy-wall ware which is characteristic of the output of the chemical plant section, other means of speeding up annealing have been found. The annealing oven used for chemical glassware is an interesting example of development from another industry. It is an electric oven designed in co-operation with the Midlands Electricity Board and the oven builders, Shelley Electric Furnaces, Limited, Longton, Stoke-on-Trent, and is based on a type used in pottery manufacture.

The annealing oven consists of an electrically-heated cowl which can be lifted by an overhead electric hoist, and deposited on a base, which has previously been loaded with glassware. A controlled heating and cooling cycle then commences, at the end of which the oven is lifted off and placed on another base, which is ready loaded. There is a considerable saving in heat, and a large increase in throughput.

It is a matter of interest that the large increase in output has been absorbed without any substantial change to the labour force, and the extra production is being disposed of in new markets, particularly overseas, which the company have developed in recent years.

Continuing **Production**

CONTROL OF STRIP WIDTH IN HOT ROLLING MILLS

A servo-driven optical arrangement for the monitoring of deviations in the width of the products of a continuous hot wide-strip rolling mill has been installed in works of the Steel Company of Wales Limited. This, the Evershed width gauge, has been developed from a system initiated by the British Iron and Steel Research Association and is produced by Evershed and Vignoles Limited, Acton Lane Works, Chiswick, London, W.4. The system relies upon the natural radiation of infra-red rays from the strip and is sufficiently sensitive to respond to material which has cooled to a very dull red.

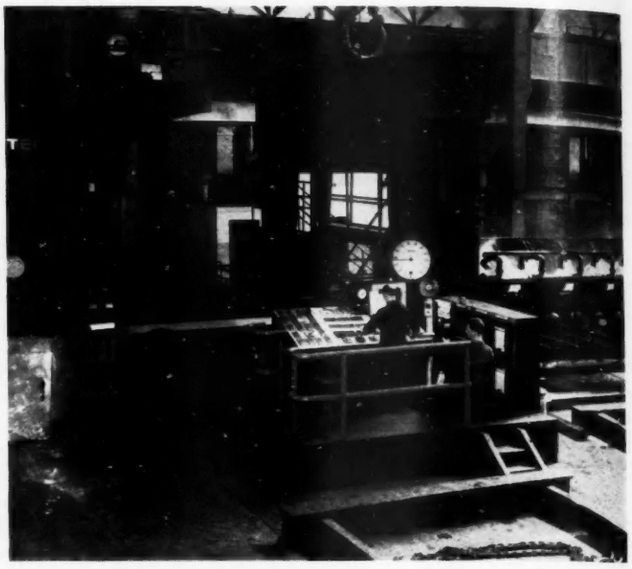
Two edge "followers" are used, each of which tracks the individual motions of the edges, the combined readings being summated electrically to give a signal proportional to the deviation in total width. The arrangement is shown in the illustration and, in this, the followers are mounted on a traverse in a gantry above a foot bridge which straddles the mill roller table a few feet above the run of the strip. The traverse consists of two motor-driven lead screws enclosed in an oil-filled trunk upon which the two followers slide. The $\frac{1}{2}$ h.p. traverse motor is at the left-hand or remote end of the gantry, and at the right-hand or near side end is a shaft extension coupled by bevel gearing to the circular indicator, seen in the right centre of the illustration, for the setting of the nominal width. The indicator is purely a mechanical arrangement of two pointers and dials and is calibrated to read over the whole range of widths to the nearest $\frac{1}{32}$ in.

The method of detecting and tracing the change in the edge position of the strip reduces, to the minimum, variations which may arise in signal strength due to fluctuations in the rolling temperature. The radiation from the surface of the strip is projected through a lens and prism on to two photo-electric cells, placed side by side. One of the cells receives a constant amount of energy from a section of the strip some distance inside the edge while the other cell is activated by the edge itself. The movement of the edge increases or decreases the radiation upon this cell dependent upon the direction in which the strip moves. A shutter is driven across the face of the other cell, reducing the energy upon it to a value equal to that obtained by its neighbour. This system of balancing radiation, it is pointed out, ensures freedom from temperature effects.

Each follower is self-contained inasmuch as it consists of an optical and photo-electric sensing device which presents a "chopped" signal to a built-in 50 c/s amplifier, the output of which drives the shutter mechanism by means of a small alternating-current servo-motor. Adjustable damping is provided by means of tacho feedback derived from a small generator attached to the end of the motor. The unit operates on a 50 volt single-phase supply.

A small panel mounting a roll-chart recorder is employed for the continuous recording of the nominal width of the strip and deviations of up to $\pm$ 3 in. One remote indicator, also calibrated to $\pm$ 3 in., is mounted flush in the top of the finishing operator's control desk, which also contains the push buttons for the control of the traverse motor. Any number of indicators may be utilised as the system employs conventional milliammeters wired in series and additions may be made to the loop at any time.

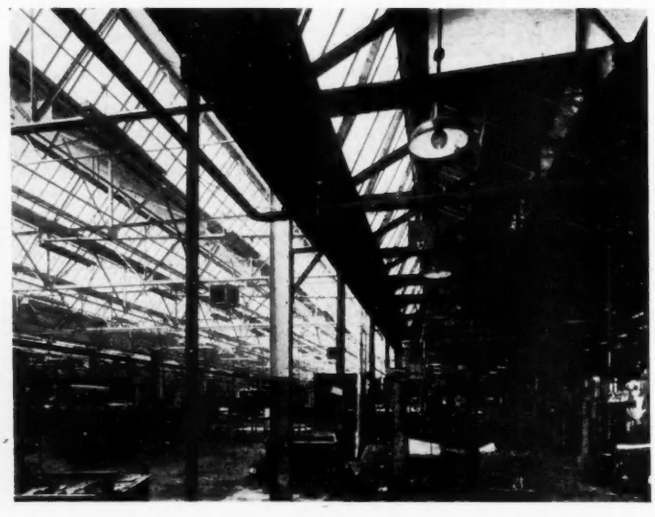
The cooling of the apparatus mounted above the hot strip is necessary and a supply of water must be provided for this purpose.



The Evershed gauge for recording the width of hot strip leaving a rolling mill is a servo-driven optical arrangement utilising the natural radiation of infra-red rays from the strip. Two edge "followers," mounted on a traverse straddling the strip, are employed.

OIL-ENGINE WORKS MODERNISED

Petters Limited, established as internal combustion engine makers in 1895, became associated with the Brush Group in 1938, and in 1957, when Brush was acquired by the Hawker Siddeley Group, the Petter business became a wholly-owned subsidiary of the latter organisation. For some years Petters have concentrated on the manufacture of small engines at Staines, Middlesex, where they took over the former Lagonda car works in 1947. Production of petrol and diesel engines in the range $1\frac{1}{2}$ to 20 b.h.p. is now at the rate of an engine about every two minutes, and plans are in hand for doubling this production rate by 1962.



One of the features of the development plan at Petters Limited, Staines, is the replacement of 60,000 sq. ft of wooden roof by a steel structure. The old roof (on the right) and the new one (left) are clearly visible in this illustration.

When the plans for increased output were formulated in 1956, they were based on the fact that full production must be maintained while the improvements were carried out, and the organisation involved was complicated. In the first place, the existing factory roof, which had been built as a temporary structure in 1914, was of wood, gave only 12 ft of headroom, and was incapable of carrying suspended loads such as conveyor rails. Secondly, the factory floor level varied by as much as 14 in., making movement of materials and products difficult. Thirdly, a new range of air-cooled, lightweight diesel engines, known as the "PC" range, was being introduced and for this purpose 84 new machine tools would have to be incorporated in the production lines. Fourthly, the materials stores were of the fixed bin type, and mechanisation would be needed to improve handling.

The plans were drawn up on a five-year basis, divided into nine stages, and the first three of these have now been completed. This work has involved the replacement of over 60,000 sq. ft of the old wooden roofing by a steel-frame structure, the re-organisation of the machining lines so that production flow is towards the eventual site of the assembly lines, test shop, paint shop and dispatch area, and the incorporation in the machining lines of more than £250,000 worth of new machine tools for the "PC" range of engines.

Large diagrammatic charts placed on notice boards throughout the factory gave employees the full facts about every phase of the operation, and as a result the work has been accomplished without any difficulties or complaints.

While the building work was in progress pallets were introduced into the stores, and all incoming castings are now handled by two standard sizes of pallet, 30 in. by 30 in. by 18 in. box type for general use, and 40 in. by 48 in. flat type for heavy castings such as flywheels and crankcases. For the storage and handling of small parts in the machine shop a standard 12 in. by 12 in. by 6 in. tote pan has been introduced. During the re-organisation an airless type shot-blast plant has been installed, to deal with 35 tons of castings a day, and several special-purpose machine tools are now in operation as a step towards automatic production.

NOTICES OF MEETINGS

British Institution of Radio Engineers

LONDON
"Electronics in Medicine," by R. F. Farr. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Mar. 26, 6.30 p.m.
CARDIFF
"Television Lighting Effects," by A. E. Robertson. South Wales Section. Department of Physics, University College of South Wales, Cardiff. Wed., Mar. 26, 6.30 p.m.
MALVERN
"Transistors in Reception," by L. E. Jansson. South Midlands Section. Winter Gardens, Malvern. Fri., Mar. 28, 7 p.m.
MANCHESTER
"Electronic Handling Technique," by R. N. Settle. North Western Section. College of Technology, Sackville-street, Manchester, 1. Wed., Mar. 26, 6.30 p.m.

Building Centre

LONDON
Films on "Multi-Storied Flats in No-Fines Concrete," exhibited by George Wimpey and Co., Ltd. Wed., Mar. 26, 12.45 p.m.

Chemical Society

BRISTOL
"Stereochemistry and the Transition Metals," by Professor R. S. Nyholm. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., Mar. 27, 6.30 p.m.

Combustion Engineering Association

BIRMINGHAM
"Feedwater Systems and Ancillary Equipment," by C. G. Scolding, at 10.30 a.m. "Effect of Coal Characteristics on the Operation of Mechanical Stokers," by G. G. Thurlow, at 2.30 p.m. Midland Region. Birmingham Exchange and Engineering Centre, Stephenson-place, Birmingham, 2. Wed., Mar. 26.

Illuminating Engineering Society

BIRMINGHAM
"Lighting in Relation to Modern Ceilings and Roofs," by Derek Phillips. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Mar. 28, 6 p.m.
LEEDS
"Street Lighting in Leeds and Remote Control Systems," by K. J. Goddard and T. C. Holdsworth. Leeds Centre. Lighting Service Bureau, 24 Aire-street, Leeds, 1. Mon., Mar. 24, 6.15 p.m.*
LEICESTER
"Television Studio Lighting Equipment," by K. R. Ackerman. Leicester Centre. Offices of the East Midlands Electricity Board, Charles-street, Leicester. Mon., Mar. 24, 7 p.m.

Incorporated Plant Engineers

BRISTOL
Annual General Meeting. Western Branch. Grand Hotel, Bristol. Tues., Mar. 25, 7.15 p.m.
LEEDS
Annual General Meeting. West and East Yorkshire Branch. The University, Leeds. Mon., Mar. 31, 7.30 p.m.
SHEFFIELD
Annual General Meeting and Film Display. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Mar. 27, 7.30 p.m.

Institute of Fuel

LONDON
"Dewatering of Fine Coal," by Dr. V. R. Gray. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Mar. 26, 5.30 p.m.*
BIRMINGHAM
"Reactor Operation and Fuel Element Processing at Windscale Works," by T. Tuohy. Midland Section. James Watt Institute, Great Charles-street, Birmingham, 3. Thurs., Mar. 27, 6.30 p.m.
GLASGOW
Annual General Meeting, at 5.30 p.m. "Domestic Heating Appliances," by R. H. Rouse, at 6.30 p.m. Scottish Section. Royal College of Science and Technology, Glasgow. Thurs., Mar. 27.
LIVERPOOL
Annual General Meeting. "Process Steam," by L. G. Northcroft. Merseyside Sub-Section. 9 The Temple, 24 Dale-street, Liverpool. Thurs., Mar. 27, 7 p.m.
SHEFFIELD
Annual General Meeting. Yorkshire Section. Royal Victoria Hotel, Sheffield. Wed., Mar. 26, 2.30 p.m.

Institute of Marine Engineers

LONDON
Lloyd's Register Lecture for Students. "The Free Piston Engine," by P. A. Watson. Thurs., Mar. 27, 5.30 p.m.*

Institute of Metals

LONDON
Annual General Meeting. "New Protective Coatings for Metals," by W. E. Ballard. London Local Section. Thurs., April 3, 6.30 p.m.*

Institute of Physics

LIVERPOOL
"New Methods for Studying the Electronic Structure of Metals," by Dr. A. B. Pippard. Liverpool and North Wales Branch. Department of Electrical Engineering, The University, Liverpool. Fri., Mar. 28, 7 p.m.*

Institute of Refrigeration

LONDON
"An Experimental Study of the Use of Mixed Refrigerants for Obtaining Cooling Over a Temperature Range," by Drs. G. G. Haselden and L. Klimek. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Tues., April 1, 5.30 p.m.*

Institution of Civil Engineers

LONDON
"Flow in Alluvial Channels with Sandy Mobile Beds," by Gerald Lacey. Tues., Mar. 25, 5.30 p.m.*
LIVERPOOL
"Foundation Problems in the North Western Area," by J. K. Alderman. North Western Association. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., Mar. 28, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"The Atomic Clock," by Dr. L. Essen. Measurement and Control Section. Tues., Mar. 25, 5.30 p.m.*
"Objective for Euratom," by F. Giordani. Supply Section. Wed., Mar. 26, 5.30 p.m.*
"Future Radio-Communication Methods for Civil Aircraft," by W. E. Brunt. Radio and Telecommunication Section. Mon., Mar. 31, 5.30 p.m.*
CHATHAM
"Application of Nuclear Energy to Power Production," by T. R. Puzey. London Graduate and Student Section. Medway College of Technology, Chatham. Thurs., Mar. 27, 7 p.m.
GLASGOW
Faraday Lecture on "The Electrification of the British Railways," by the late G. H. Fletcher, read by R. Ledger. South East and South West Scotland Sub-Centres. Royal College of Science and Technology, Glasgow. Thurs., Mar. 27, 7 p.m.
LEEDS
Discussion on "Teaching of Electricity Supply," opened by G. Shepherd. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Mar. 25, 6.30 p.m.
NEWCASTLE UPON TYNE
"Design of a 330 kV Transmission System for Rhodesia," by F. C. Winfield, T. W. Wilcox and G. Lyon. North Eastern Centre. Neville Hall, Westgate-road, Newcastle upon Tyne. Mon., Mar. 24, 6.15 p.m.
NOTTINGHAM
"Practical Considerations of Mine Electrification," by G. Rutter. East Midland Centre. College of Arts and Crafts, Nottingham. Tues., Mar. 25, 6.30 p.m.*
PORTSMOUTH
"System Control of the Electricity Grid," by J. Williamson. Southern Centre. Offices of the Southern Electricity Board, Cosham, Portsmouth. Wed., Mar. 26, 6.30 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
"Design Considerations in Floor Heating," by E. Danter. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Wed., Mar. 26, 7 p.m.

Institution of Highway Engineers

NORWICH
Annual General Meeting and Film Evening. East Anglia Branch. Assembly House, Norwich. Tues., April 1, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "The Ultimate Engine: Stationary, Rail Traction and Marine." Internal Combustion Engine Group. Fri., Mar. 28, 6 p.m.*
BIRMINGHAM
"Test Bed Installations and Engine Test Equipment," by H. G. Freeston; and "Type Testing," by Lieut.-Col. R. A. Laurence. Birmingham A.D. Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Mar. 25, 6.30 p.m.
BRISTOL
"Turbo-Charging of High-Speed Diesel Engines: Present Position and Future Prospects," by C. H. Bradbury. Western A.D. Centre. Royal Hotel, Bristol. Thurs., Mar. 27, 6.45 p.m.
COLCHESTER
"The Steam Catapult," by Commander C. C. Mitchell and Captain Q. H. Paterson. Eastern Branch. Red Lion Hotel, Colchester. Tues., Mar. 25, 7.30 p.m.
CRAWLEY
"Quality Engineering," by F. Dixon. Southern Branch. At works of Edwards' High Vacuum Ltd., Manor Royal, Crawley. Wed., Mar. 26, 6 p.m.
SHEFFIELD
"A Review of Applications of Radioisotopes in Engineering," by D. B. Smith. Yorkshire Branch. The University, St. George's-square, Sheffield. Wed., Mar. 26, 6.30 p.m.

Institution of Naval Architects

LONDON
Spring Meeting:
Annual General Meeting. "Brittle Fractures in Welded Ships," by J. Hodgson and G. M. Boyd. Tues., Mar. 25, 10.15 a.m.
"Design, Construction and Operation of a Class of Twin-Screw Tugs," by Dr. E. C. B. Corlett, J. Venus and C. H. Gibson; and "Progressive Towing Trials for Full-Scale Inland and Shallow-Draught Vessels," by J. Sweet, at 10.15 a.m. "Losses of Small Ships," by C. V. Manley; and "The Hydrofoil Boat: Its History and Future Prospects," by P. R. Crewe, at 2.30 p.m. Wed., Mar. 26.
"Scale Effect Experiments on Victory Ships and Models—Part II," by Dr. Ir. J. D. van Manen and Ir. A. J. W. Lap; and "Effect of Surface Roughness on the Performance of a Model Propeller," by J. M. Ferguson. Thurs., Mar. 27, 10.15 a.m.
Annual Dinner. Grosvenor House, Park-lane, W.1. Tues., Mar. 25, 7 for 7.30 p.m.

Institution of Production Engineers

BARROW-IN-FURNESS
"Electronic Control of Machine Tools," by D. T. N. Williamson. Preston Section. Technical College, Abbey-road, Barrow-in-Furness. Fri., Mar. 28, 7.30 p.m.
COVENTRY
"Ceramic Tools," by H. Eckersley. Midlands Region. Sibree Hall, Coventry. Mon., Mar. 24, 7 p.m.
GLASGOW
"Radioisotopes," by Dr. Henry Seligman. Glasgow Section. St. Enoch Hotel, Glasgow. Mon., Mar. 24, 7.30 p.m.
LINCOLN
Annual General Meeting and Film Evening. Lincoln Section. Ruston Club, Lincoln. Thurs., Mar. 27, 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
"Ageing of Rubber: Effects of Metallic Contamination," by B. N. Leyland and R. L. Stafford. Manchester Section. Grand Hotel, Manchester. Mon., Mar. 24, 6.45 p.m.

Institution of Structural Engineers

LONDON
"Housing the Dounreay Fast Reactor," by N. T. Barrett. Thurs., Mar. 27, 6 p.m.*

Junior Institution of Engineers

LONDON
"Photocopying and the Drawing Office," by G. V. Rickards. Fri., Mar. 28, 7 p.m.*

Manchester Metallurgical Society

MANCHESTER
"Some Metallurgical Aspects of Nuclear Power Development," by Dr. H. K. Hardy. Central Library, Manchester. Wed., Mar. 26, 6.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Water-Lubricated Bearings in Marine Use," by A. D. Newman. Mining Institute, Neville Hall, Westgate-road, Newcastle upon Tyne. Mon., Mar. 31, 6.15 p.m.*

Reinforced Concrete Association

EDINBURGH
"The Scottish Agricultural Industries Ltd., Leith Development," by L. Gordon. Scottish Branch. North British Hotel, Princes-street, Edinburgh. Tues., Mar. 25, 6.30 p.m.*

Royal Aeronautical Society

LONDON
British Commonwealth Lecture: "Why Airlines Are Hard to Please," by B. S. Shenstone. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Mar. 27, 6 p.m.*

Royal Institution

LONDON
"Magnetism," by Professor W. E. Curtis. Sixth Formers' Lectures. Tues. and Wed., Mar. 25 and 26, 5.30 p.m.

Royal Statistical Society

LEICESTER
"Methods of Productivity Measurements," by Dr. T. E. Easterfield. Leicester Industrial Applications Group. College of Technology, Leicester. Thurs., Mar. 27, 7 p.m.
SHEFFIELD
"Automatic Sales Forecasting," by A. Muir. Sheffield Industrial Applications Group. Y.M.C.A., 49 Fargate, Sheffield, 1. Thurs., Mar. 27, 7 p.m.*

Royal United Service Institution

LONDON
"Impact of Reductions of Defence Requirements on British Industry," by A. A. Shenfield. Wed., Mar. 26, 3 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"The Acid Bessemer Process of To-Day," by F. B. Cawley. B.I.S.R.A. Laboratories, Sheffield. Tues., Mar. 25, 7 p.m.

Society of Chemical Industry

MANCHESTER
"Recent Research on the Corrosion of Boiler Tubes," by Dr. E. C. Potter. Corrosion Group. Robinson Lecture Theatre, The University, Manchester. Fri., Mar. 28, 6.30 p.m.

Society of Instrument Technology

LONDON
Symposium on "The Evaluation of Instruments for the Process Industries." Manson House, Portland-place, W.1. Tues., Mar. 25, 7 p.m.*
GLASGOW
Annual General Meeting. Presidential Address by Sir Harold Hartley. 425 Sauchiehall-street, Glasgow, C.2. Fri., Mar. 28, 7.15 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester 3.
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94/98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Royal United Service Institution, Whitehall, London, S.W.1. (WHItehall 5854.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)

Engineering at Home

FILM TO PROTECT SURFACES

Solvent-based strippable coatings have been used for some time as temporary protectives for various purposes, but grades suitable for putting over surfaces already coated with paints and varnishes have been in short supply, because the solvents usually employed in protectives are those which are able to soften and remove paints. Mastrip is claimed by its makers, Croda Limited, Goole, Yorkshire, to be a strippable coating composition that does not affect paint, baked enamels, or furniture lacquer. They say it does not cause lifting, marring, or other irregularities to painted surfaces by solvent or plasticiser action.

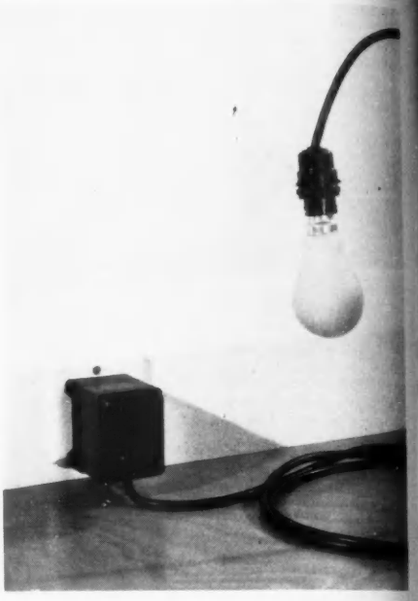
Mastrip strippable protective is intended for use as a protective barrier or masking material for protection of painted and high-finish surfaces against abrasion, handling, and general mechanical damage. It is intended to provide a barrier against water vapour, free water, and light; and will conform to the contours of any article to which its is applied.

The material is a blend of polymeric materials, solvents, stabilisers, and pigmenting compounds. The colour of the standard material is grey. Mastrip is formulated particularly for spray applications, although brushing and dipping is also feasible if the material is ordered specifically for this type of application. It is suitable for application by pressure spray equipment, for example, using a gun nozzle of 0·070 in. It can be sprayed smoothly on to a vertical surface without sagging. The drying time is about 30 minutes. If five coats are applied at 30 minute intervals, the time to "hard dry" is about 24 hours.

Although the adhesion of Mastrip to surfaces is insufficient to prevent its removal by stripping, it gives sufficient adhesion to prevent spontaneous peeling if the film is accidentally broken. Cuts or slits in the film can be repaired by brush application of the liquid material. The dried film of the material is non-inflammable, but the liquid as supplied is highly inflammable. The solvent components do not normally cause discomfort or injury to people engaged in applying the materials but good ventilation is essential. The material can be stored for long periods.

TRANSFORMER PLUG

A plug that embodies a transformer is produced by the Dohm Group, 167 Victoria Street, London, S.W.1. Like an ordinary plug, it fits into a three-pin socket carrying the existing mains supply. It steps down the supply from 240 to 25 volts and is intended to safeguard the users of items with trailing leads, such as inspection lamps, soldering irons, and electric tools. A frayed lead, a defective connection on the appliance, a breakdown in insulation, or a wet floor can lead to fatal accidents if the operating voltage is in the region of the mains voltage. The Chief Inspector of Factories has emphasised in his report that to ensure safety "the problem is usually best tackled at source, i.e., by reducing the voltage of the supply to the portable apparatus." The company claim that the Dohm Electran transformer plug makes it possible to cut right through the lead connecting the plug and the appliance without the slightest shock. The plug, illustrated above, is constructed and cased in hard oil-resistant rubber. Power capacities of 25 and 40 watt are available.



The transformer plug steps the voltage down to 25 volts to safeguard the user of electrical equipment on long leads.

UNDERFLOOR AIR-FEED

The Redfyre No. 5 Bacboiler uses an underfloor air-feed fire; an air control regulates the rate of combustion. Newton Chambers and Company Limited, Thorncliffe, Yorkshire, make the appliance. They are showing it publicly for the first time at the Ideal Home Exhibition.

The space heating capacity of the new unit is 1,500 cu. ft. The boiler will serve a 30 gallon cylinder plus 50 sq. ft of radiators, including pipework. The fire has a cast iron vitreous enamel fret, which is firebrick lined. There is a removable deepening bar. A reversible extension plate is available as an extra. The bottom grate is of heat resistant 30 per cent chrome semi-steel and is reversible for burning coal or coke. The mild steel ashpan is large and should only need emptying twice a week. Cast iron is used for the boiler; a corrugated front aids coke burning.

For householders who want a hearth-level fire, to burn coal only, there is a low-fronted version—the Redfyre No. 5A Bacboiler. The design is the same except that the deep fret and firebrick are replaced by a shallow fret and a cast iron protection strip. The space heating capacity is the same but the hot water output is lower (30 gallon cylinder plus 30 sq. ft of radiators).

ANAMORPHIC LENS FOR 8 MM FILMS

The development of substandard film systems for amateur use has followed the developments in professional entertainment films. Thus, not only are standard and telephoto lenses available to amateurs but so also are zoom lenses—the vari-focal lenses that allow cine-photographic effects previously only obtainable with commercial film equipment. Anamorphic lenses are also available to provide wide-screen pictures in the home.

J. D. Möller Optische Werke G.m.b.H., Wedel, Germany, claim to be the first company in Europe to market anamorphic lenses for the reliable projection of CinemaScope films. The company have also produced 8 mm and 16 mm lenses for the substandard film used by amateurs. However, because amateur projectors do not usually provide the high light output of the cinema machines, the "Moller" substandard film anamorphic lenses operate with an expansion factor of 1·5, compared with the expansion factor of 2·0 for cinema lenses. The picture is expanded to 1·5 times its normal width.

A feature of the lenses is that they can be used for both projection and cine-photography. With adaptors they are placed before the lens of the film camera in shooting film, and before the lens of the film projector in reproducing it.

SANDWICH BOARDS

A Warerite-faced hardboard has been introduced by Bakelite Limited, Grosvenor Gardens, London, S.W.1. Known as Warerite wallboard, the material consists of a high-density fibre-hardboard core surfaced on both sides with melamine resin impregnated papers moulded under heat and pressure. One face carries a decorative pattern, the other is a plain compensating surface to protect the core from moisture and warping.

The new wallboard is intended for surfacing walls, ceilings, flush doors, partitions, counter and shop fronts; the company claim that its hygenic, moisture-resistant properties make it particularly suitable for use in kitchens, bathrooms and other steamy atmospheres. With a thickness of $\frac{1}{8}$ in., the material can be cut to a required shape with an ordinary hand saw or with power saws. It can be finished by filing or sanding. The edges exposed by cutting can be protected from the effects of moisture by sealing with paint.

The wallboard can be screwed or pinned to timber grounds fixed to the wall: the joints can be masked with timber, metal, or plastics beading. An alternative method is to use extruded metal or plastics fixing sections. Sixteen patterns and colours are available.

ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

CHAIRMAN: J. A. Dixon, M.A., A.M.I.Mech.E.
EDITOR: F. B. Roberts, M.B.E., A.M.I.Mech.E., A.M.I.Loco.E.
DEPUTY EDITORS: D. Fisher, Ph.D., B.Sc., A.M.I.C.E., A.M.I.Mech.E.; E. P. Ward, M.A., A.M.I.Mech.E.
ASSISTANT EDITORS: E. I. Brimelow, M.Eng., Assoc.I.Mech.E., A.I.M.; J. E. Dodsworth; W. K. V. Gale, M.I.S.I.; J. T. Godfrey; R. Lemmy, A.I.M., M.I.S.I.; M. Neal, B.Sc., D.I.C., A.F.R.Ae.S.; R. G. Pay, M.Sc.; A. A. H. Scott, B.Sc., A.M.I.Mech.E.
SUBSCRIPTION MANAGER: G. A. Roberts.
ADVERTISEMENT MANAGER: G. H. Dixon.

Annual subscription rates: Inland and abroad £5 10*s*. (Canada, £5 5*s*.). Three months, 27*s*. 6*d*. all countries. Single copies, 2*s*. 7*d*. post free.

Engineering Information Service: Assistance is available from Engineering Information Service in obtaining information, and in locating sources of information, both technical and commercial. E.I.S. deals with, for example, names of makers and suppliers of plant and equipment, technical data on design, markets for engineering products, and compilation of references to information on specific topics. Inquiries should be addressed to Engineering Information Service at the address given in the left-hand column.